Ohio Agricultural Experiment Station.

BULLETIN 92

WOOSTER, OHIO, MARCH, 1898.

PRELIMINARY REPORT UPON DISEASES OF THE PEACH.
EXPERIMENTS IN SPRAYING PEACH TREES.

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BULLETIN

OF THE

Ohio Agricultural Experiment Station

NUMBER 92. MARCH, 1898.

I. PRELIMINARY REPORT UPON DISEASES OF THE PEACH.

BY AUGUSTINE D. SELBY.

THE PEACH INDUSTRY IN OHIO.

The beginning of peach growing in Ohio dates from the early settlement by the whites. If there were aboriginal orchards of this fruit, we have lost the records of them. With the great cornfields of the Indians, few orchard fruits were found, and in spite of Johnny Appleseed's labors in scattering the seeds which earned him that deathless title, the white settler needed to plant his own peach stones. This sort of planting was almost universal. If the settlers lacked seed, the want was supplied through the aid of friends in eastern settlements by the hands of a new arrival.

Thus seedling trees of the peach were planted in fence rows or sprang up unhindered from castaway pits. Early orcharding was chiefly of this kind. The trees were grown almost entirely in out-of-the-way places; and of all these corners no others were so generally used as the angles of the Virginia rail fence. The care and attention devoted to early orchards are indicated by the places, the situations, given the trees. The fruit crop was an incident of farming. The trees were usually left unpruned, except by occasional overloading, and the product was looked upon as nature's care, not man's. That more attention on his part might lead to a better return, could scarcely claim much thought from one beset by the burdens of pioneer life. Under these conditions of new land, forest protection and propagation from seed, it must be admitted that the results were often good. That they were better than now obtained by the same treatment may also be true. Conditions have changed in many ways.

We have no early statistics of peach crops in Ohio. The earliest data at hand are those gathered in 1868, in pursuance of the amended

law of April 3, 1868. Previous to that date no statistics of orchard products were collected, consequently little can be done to supply the lack.

The yield of peaches for the state in 1868 was 599,500 bushels; for 1869, 1,426,200 bushels. The total production reached its lowest point in 1875, with 36,360 bushels, and in 1884 with 24,490 bushels. The largest yields were in 1874, 2,235,574 bushels; in 1878, 1,476,160 bushels; in 1888, 1,594,890 bushels, and in 1896, the banner yield of recent years, 1,-

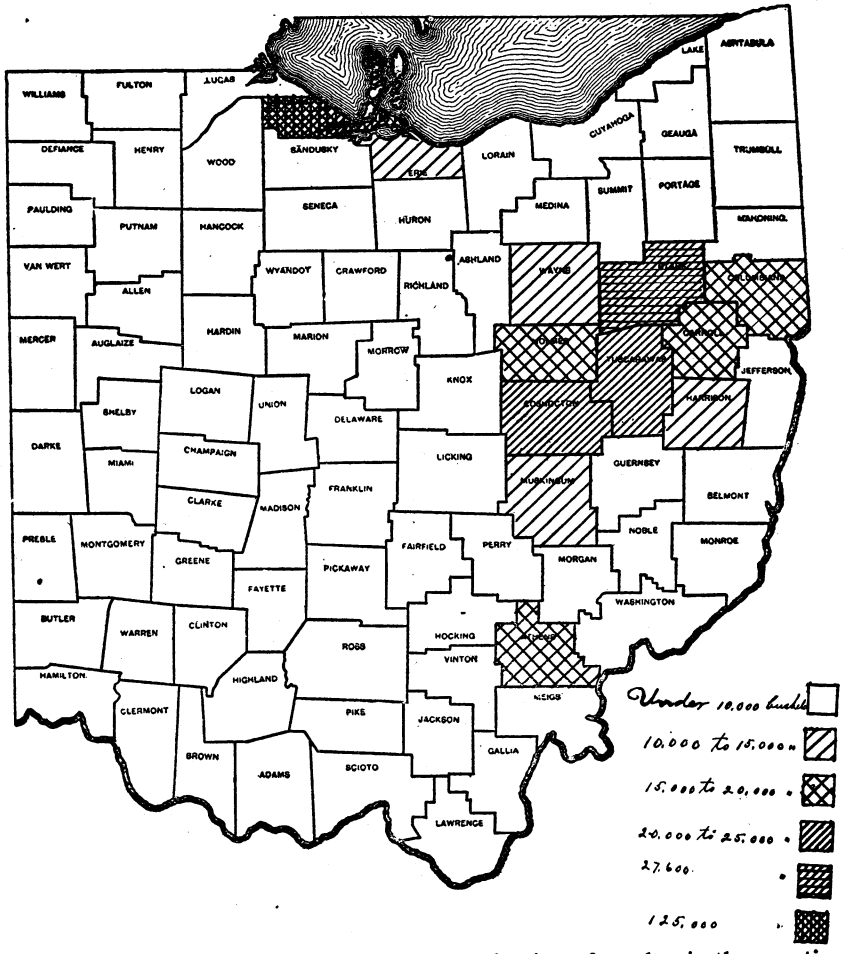

FIG. 1.—Map showing the average annual production of peaches in the counties of Ohio, for five years, 1890 to 1894.

935,514 bushels. The centers of average production for the five years from 1890 to 1894, and the crops for the year 1896 are shown in maps (Figs. 1 and 2). The average annual production for 1890-1894 in the state was 538,097 bushels, for the decade from 1880 to 1889 it was 696,516 bushels and for the 10 years, 1870-1879, 609,452 bushels.

For the period of 1890–1894 the largest production of peaches in one year was in Ottawa county for 1894, and amounted to 306,858 bushels.

The largest yield from any county for any year was from Ottawa in 1895, when that county produced 488,844 bushels out of a total of 642,295 bushels for the entire state.

The most striking fact in later Ohio production is its greater concentration, and then making it the subject of greater care and study where pursued. The favored situation of the "Peninsula" and "Island" district north of Sandusky Bay has gradually been recognized, while the

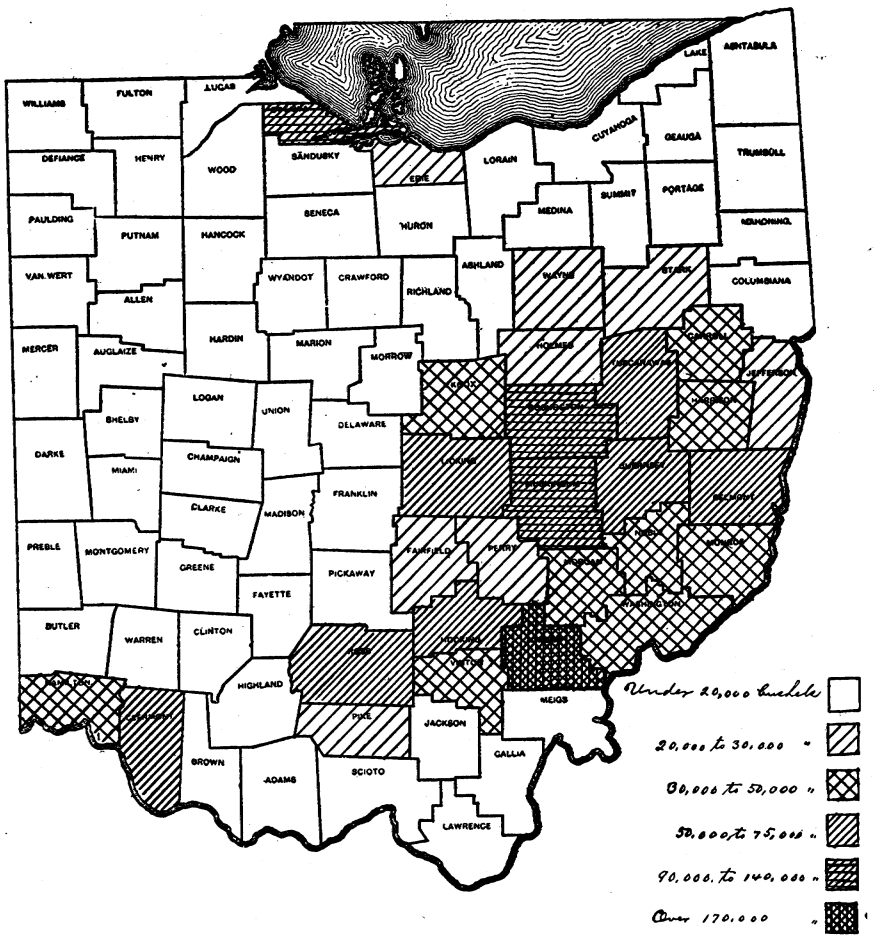

FIG. 2.—Map showing production of peaches in the various counties of Ohio in 1896

same may be said of certain elevated lands of the hill regions. Especially has the superiority of the clay soils in the hilly counties been but recently realized.

In general, the attitude of the grower toward the peach crop also has changed. The fence corner no longer yields profitable investments in peach growing; borers, leaf curl, yellows, and other troubles make the

trees short-lived or the fruit inferior. The poorest land, irrespective of situation, offers the same disadvantages. Only suitable land, of fair quality, with care and labor in pruning, training, and cultivation, may yield an adequate return to the orchardist. We have passed the "grow as you please" method of peach culture, and reached one of labor for a definite end; of specialization for a specific return. Despite the winter killing of peach fruit buds and other drawbacks, the science of peach culture has gained recognition. No such science can omit the serious problem of peach diseases, nor leave out its companion subject, that of spraying with fungicides to control certain of them. The practical questions of what to apply, and how and when to do it, will be discussed under each fungous disease and in the statement of results of spraying experiments.

NEED FOR THE STUDY OF PEACH DISEASES.

As culture is intensified, factors before unseen are brought to the front. The trite observation that there is scarcely a limit to the number of new diseases, has some foundation in experience. How much is due to intensive observation or interest and how much to actual n iplication of parasitic troubles is not often clear.

New diseases appear from time to time; the pustular spot of the peach and possibly the gum-flow twig trouble and crown gall, page 208 belong in this class. On the other hand, peach rot, leaf curl and yellows have apparently been present ever since the culture of peaches was begun in the state. It is the specific trouble which intervenes to cut off the anticipated profits of the fruit grower that receives careful notice. With simple gathering of the fruit crop and no further attention until the next is ready to pluck, the diseases, like the crops, are a matter of course. They express nature's supposed method of growing these things. But man is an active agent in the procedure. He introduces other conditions than the natural ones, and by importation of stocks, etc., scatters the diseases or insects found in centers of older culture to the newest and remotest portions of the earth. Man has learned likewise to be a factor of another sort, he has devised methods of prevention. These are needed to maintain a proper equilibrium of forces.

In 1893 some peach orchards in Ohio were almost defoliated by the leaf curl fungus. One orchardist of Ottawa county estimated his loss at 40 per cent. of the peach crop on a certain variety of which he had large plantings. Peach trees universally suffered from the curl. In addition, much of the Michigan fruit of 1894 was observed to be spotted and pimpled, having its appearance badly damaged. The crown gall of the trees and roots appeared to an unusual extent. Other less usual or less conspicuous troubles were made the subject of frequent inquiry at the Experiment Station. Accordingly a special study of peach diseases was begun in 1895. The numerous troubles brought to light seem to have

warrant.d the inquiry. Legislation in the state has recognized this department in making the officer in charge the referee in cases of dispute under the black-knot yellows law of 1896.

SCOPE OF THE PRESENT INVESTIGATION.

The present report shall aim to deal with the diseases of the peach tree (*Prunus Persica* L.) in Ohio. Only such diseased conditions as have been observed or reported in the state will be treated; a few references to diseases found elsewhere will be cited. By a diseased condition or a "disease," is meant any marked deviation from the average or normal life symptoms of a plant. The study of disease or abnormal life functions, that is, pathology, is therefore correlated with the study of normal life functions or physiology. Under average conditions, such as surround peach trees receiving good care, the leaves and blossoms put forth in spring and the leaves fall in autumn. If blossoms and new leaves put forth again in autumn, this indicates an abnormal condition of the plant. In like manner, the tree has an average or normal life period. Hastened death, with other than normal growth of leaves and branches, leads us at once to say that the plant is diseased. Something has prevented the ordinary course of the life of the tree in question. The fruit of the peach is uniform in color and texture except for shading of red, green, or white and yellow, the one into the other, or for the mellowing of ripeness; red or white, dark or black spots upon the surface, or small softened areas in the flesh, indicate disease. It is not normal for peach leaves to be punctured through the dying of tissue in spots and the dropping out of this dead area, nor for the leaves to be coated with a white growth.

In other words, any great deviation from the normal functions of a living plant, as shown by a variation from normal appearance exhibiting symptons of these functions, will be called a disease. Such deviations as are known to result from the attacks of insects will not be discussed in this bulletin except to distinguish some of them from specific diseases referred to other causes.

The discussion will be given under five subdivisions:

I. Diseases due to mechanical agencies or to unfavorable soil conditions.

II. Injuries due to atmospheric conditions.

III. Diseases referred to unknown or doubtful causes.

IV. Fungous diseases of the peach.

V. Diseases caused by animal organisms other than insects.

I. DISEASES DUE TO MECHANICAL AGENCIES OR TO UNFAVORABLE SOIL CONDITIONS.

1. WOUNDS.

While the matter of wounds is always important there are reasons which make this especially noticeable with the peach. Any wounding of a plant, short of what may cause immediate death, calls into action all its healing or reaction processes. The growth of wound cork or healing cork and of callus are phases of this natural healing that may be observed generally. By wound cork the injury may be covered and the danger averted or, the wounding or irritating agent continuing, there is great enlargement of the injured part. The very great enlargements figured on pp. 204, 209 of this bulletin and familiar likewise in the black-knot of the plum and cherry serve as examples of such enlargements. In the case of plate V we suggest that a continuously acting irritant would account for the results observed; while in plate III we appear to have a cumulative result, part of which is certainly attributable to an injury on the young shoots, yet the conditions of enlargement call for further explanation. May we find here that a healing balm, the exuded gum, serves as an irritant?

EXUDATION OF GUM.

With all the stone fruit trees an injury, or wound, is followed by the exudation of gum. In the conifers the exudate is a resin. In both, the office of the exuded substance, whether gum or resin, is a healing one This gum of the stone fruit trees is a covering to hasten the healing of wounds. In general we may state that the exudation of gum in the peach is a symptom of injury and not a disease itself. Gum-flow may arise from a given disease, as rosette. The technical explanation of the origin of the gum in special canals of the tissue and the situation of these canals or vessels in relation to other parts, should be sought in other works.[1] The widespread occurrence of gum upon the branches of peach trees, with the frequent inquiries about these conditions of gum-flow, call urgently for answer. Often the trunk and larger branches of a peach tree are covered with gum which exudes from a large number of shot-hole perforations in the bark. In such cases the fruit bark beetle (Scolytus) has probably eaten into the living parts and the flow of gum has followed. It is our custom, where other causes of injury can be traced, to refer the gum-flow to the other agents, and rightly so, as we have seen.

Some obscure conditions that give rise to gum-flow are more or less prevalent, and where the causes are imperfectly understood we may still describe the disease by its evident symptoms. For such the reader is referred to pp. 199–206.

[1] Frank, A. B. Krankheiten der Pflanzen I, 52, 53.

WOUNDS AND PRUNING.

The peach bears quite severe pruning without injury, and with apparent good result. The effect of severe pruning upon the trees may not be overlooked. However, as it has been in the past, more peach trees have suffered from lack of pruning at all than from too severe cutting back. This side of the question is largely a cultural one. From the view of the plant student the essential principle is to prune while the trees are dormant. There appear to be good theoretical reasons for the heavier pruning of peach trees in winter, rather than in spring. In the Ottawa county peach region most of the pruning is done in January, February and March, and very little or none at all when the buds are starting. By such winter pruning there would, perhaps, be less danger of injury to the trees.

2. UNDRAINED SOIL—WET FEET.

Peach trees require a well-drained soil. By a well-drained soil is meant one with the permanent water level at considerable depth below the surface of the ground. The ordinary muck swamp, with a water level of 18 to 24 inches below the surface, is not well drained in the sense in which the term is here used.

One or more illustrations of the effect of inadequate drainage have come under the writer's notice. In one corner of a certain orchard, where the trees were set in black soil with stiff under-clay, it was noticed that the foliage had a peculiar appearance. Parts of the leaves were of normal dark green color; other parts were much lighter colored. The light colored parts were yellowish green and followed the veins and veinlets of the leaf—the natural colored portions were between. The variegated effect was quite striking and at once raised the question of "yellows." Upon tracing the conditions of soil and foliage a relation was inferred. Where the average soil passed into the darker soil with underclay, the foliage of the trees changed from the normal to the abnormal, variegated coloring just described. The owner reported an entire lack of fruitfulness among these abnormal trees. Subsequent planting of peaches has been limited to the suitable soil and no spread of the unfavorable symptoms has occurred. Small areas of a few trees or even cases of only a single tree with such an appearance of the foliage and somewhat lessened vigor have been frequently observed. At times the owners have stated that several trees in the spot or spots have shown the same appearance and given the same bad result. Any such trees are better removed and such areas better left unplanted.

I saw many peach trees that were literally drowned out in the early summer of 1896. The water did not stand upon the surface about them but stood about the roots. Given, a tree newly reset, or of a year or two years' growth after transplanting, in a situation with impervious clay

below and about the trees, we have conditions to prepare for a drowned tree. The added essential is a very rainy season in the early period of growth. This sort of drowning is more frequent, however, with trees that have just been transplanted. It is in fact asphyxiation, due to the presence of the water. Asphyxiation of shade trees may result from escaping gas, in cities, but water seems the only common agent in orchards.

II. INJURIES DUE TO ATMOSPHERIC CONDITIONS.

The atmospheric conditions of heat and cold, of moisture and dryness, and of storm and calm, exert a powerful influence for health or disease (lack of health and vigor) upon all cultivated plants. We must recognize here the influence of these conditions upon the peach tree. Since it is a semi-tropical plant, we must expect and indeed are accustomed to expect recurrent injuries, especially from freezing, to which reference will be made hereafter. Light is essential to healthy growth of plants bearing green leaves; so absence of light, or lack of enough light, entails certain unsatisfactory and unhealthy conditions. With orchard trees this form of injury is not common. Nor does it appear that the direct effects of the sun's heat upon exposed tree trunks are, *per se*, injurious. Despite the name "sun-scald" as applied to certain injuries of apple and pear trees, we must refer these injuries to the results of freezing as a direct cause. Drouth may seriously impair the vitality of trees, especially when overloaded with fruit. Doubtless this cause operated in certain peach districts in 1895. After giving due weight to all such matters we yet fear much more the possible injuries from low temperature, which we now take up.

1. SEVERE COLD—FREEZING.

The familiar injuries to peach orchards from intense cold involve chiefly the destruction or injury of trunk and branches and the killing of fruit buds. To the common killing back of new growth or the destruction of the entire tree must be added the severe local winter injury of the exterior of the trunk, after the manner of that called "sun-scald" in the apple.

The winter killing of blossom buds in the peach occurs at low temperatures. Whenever the winter cold reaches or falls below –12° F. the the orchardist fears this effect. The actual winter killing is thought to occur at temperatures from –10° to –12° F. There is rarely escape for the fruit buds in any region when the cold reaches –15° F., even with the ameliorating influence of Lake Erie. It may be easily recalled that the influence of the lake is slight during midwinter, though very great during the frosts of spring and autumn. In this injury, whether by winter freezing or by untimely frosts, as in that following, the direct cause of

the death of the parts is thought to be the withdrawal of water from the protoplasm by the freezing.

Killing back of young trees or of the branches of older trees is a common occurrence likewise. As in the previous case the temperature falls below the thermal death point for the parts concerned, which are the new and somewhat immature growth having a very high percentage of water. With freezing of certain plant parts (capillary fragments of Spirogyra and Phycomyces) according to Molisch,[2] the parts give up much of their water to the formation of an external ice mantle, and internal ice formation takes place only at a temperature many degrees below the freezing point. It is a well-known fact that the matured branches of trees resist freezing injury, while immature parts are destroyed. The explanation is thought to lie in the smaller water content of the matured growth.[3] If we accept this, and acceptance seems admissible, we can understand why freezing destroys the newer parts or the parts stimulated to relatively high water content. Even when the cambium layer and the bark are apparently uninjured, the central portions of the branch or trunk are often injured, as shown by browning of these parts. Manifestly, any condition favoring late growth and unripened wood, as late rains after drouth or too late cultivation, will induce such injury. Conversely, those conditions which aid prompt maturity will tend to avoid the results just discussed. In this respect it seems that there is a possible difference between earlier and later varieties as to fruit ripening, in this line of wood maturity. Some facts stated below bear upon this point. We may have in the peach, though not so frequently as seems probable with the plum, defoliation in late summer. With the plum this results from the shot-hole fungus, Cylindrosporium, as early as July or August, followed by second foliage and bloom. Trees that have made this new growth so late in summer will have much unripened and highly aqueous tissue which will readily be injured by freezing. As before intimated, the only preventive at present known is to avoid all conditions likely to produce such a state in the tree.

WINTER INJURY TO EXTERIOR OF TRUNKS OF PEACH TREES.

The foregoing has prepared us for this part of the freezing question. Injury to the trunks of plum trees, under the circumstances just recounted, have been observed frequently. In it the bark and trunk separate, usually upon the sun-exposed sides, though the injury may be localized upon any side. The writer[4] has already discussed this question

[2] Untersuchungen über das Erfrieren der Pflanzen. 1897. See Botanical Gazette, XXIV, 437.

[3] Frank, loc. cit., I, 195.

[4] Report Ohio State Hort. Soc. 31, 1897.

in another paper but that portion relating to the peach will require restating. Upon yearling peach trees (1 year from transplanting) near Gypsum, Ottawa county, a case of serious injury to the trunks was examined in July, 1897. These trees, of several varieties, had received rather late cultivation and made a good deal of late growth in 1896. The amount of injury of the various sorts was as follows:

	Injured on trunk.	Killed.	Total injured.
Smock	30%	.....	30%
Salway	68%	8%	76%
Geary's Hold-in	4%	.....	4%
St. John (yellow)	12%	.....	12%
Lemon Free	0.	0.	0.
Brenner's	0.	0.	0.

Here it seems that the very late varieties of fruit go with a late maturity of growth. Lowheaded trees of each sort were less injured than those headed high, leaving a long bare trunk.

The injuries in question were commonly in elliptical or elongated areas upon the south and west sides of the trunks. The bark was dead over these areas and growth disclosed them as flattened or depressed. Some trees were dead, apparently from this cause. Burrill[5] has dealt with this question of injury to trunks of apple trees as well as some others. It seems that we have a similar case here in the peach. The effects of the sun in calling forth a higher water content of the cambium or "sap" layer produced just the condition for winter injury upon the restricted areas involved. This action seems in accord with that produced in the flow of liquid from the north and south sides of the maple (*Acer saccharinum* L.) cited by Burrill. In that case there was almost double the flow of liquid upon the south side that there was upon the north. The sun-exposed sides of the peach trees with a heightened water content were injured by the freezing beneath the bark, thus producing separation from the trunk.

2. WIND STORMS AND HAIL.

Storms of wind may blow off branches, especially if the trees are laden with fruit. Severe injury from hail may result in young orchards. Such was noted in Fulton county from a hailstorm in 1894. The bark was rent where the hailstones struck the trees. Except for scarring trees and shortening growth, the remote effects in this instance were not serious. The remote effects of a windstorm are often almost complete destruction of the orchard. This is best avoided by heading back and close pruning, thus giving rigidity and strength to the branches.

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[5]Report of the Trustees, University of Illinois, 1886, 283.

III. DISEASES REFERRED TO UNKNOWN OR DOUBTFUL CAUSES.

Several conspicuous and doubtful diseases of the peach still come under this head. While we have been taught the conditions of propagation and spread of part of them, we yet cannot refer the disease in question to a specific cause. The diseases of this section are in a measure physiological in character. In this way they stand in close relation to

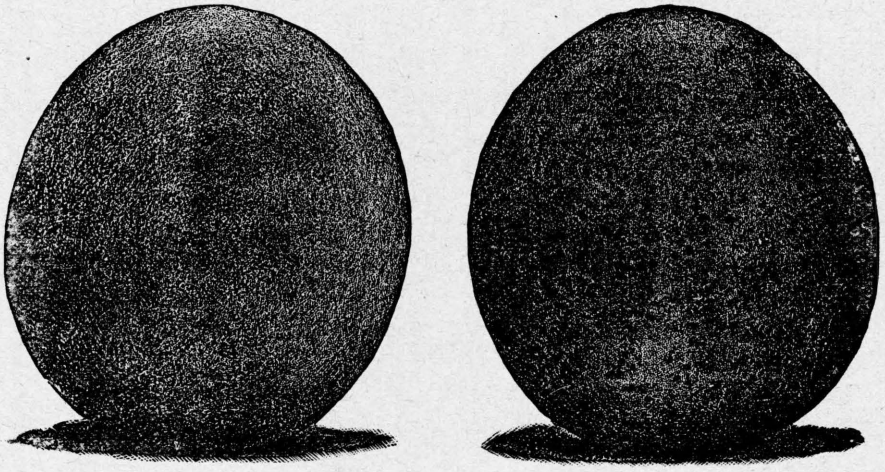
FIG. 3.—Map showing chief distribution of yellows in Ohio. Additional points of infection are known in Guernsey, Jefferson and Wayne counties but are not indicated on this map.

those in the preceding section. Unlike them the cause back of the physiological state which we call the disease, yet evades us or is but partly understood.

1. PEACH YELLOWS.

The yellows is an American disease which has been known for about one hundred years.[6] It attacks almond, apricot and nectarine trees as well as the peach, and has been recorded upon Japanese plum trees. In Ohio, yellows has been studied upon the peach only. In one instance an apricot was affected. The chief distribution in Ohio, so far as known, may be seen in the accompanying map (Fig. 3). Yellows is known to occur in the counties of Athens, Brown, Butler, Carroll, Columbiana, Coshocton, Erie, Gallia, Guernsey, Hocking, Jefferson, Lake, Lawrence, Muskingum, Ottawa, Portage, Ross, Sandusky, Seneca, Stark and Wayne. Doubtless there are other counties in which it occurs, but if so, it has not yet been made known to the writer. The prevalence is fairly well indicated in the areas outlined.

In the United States, yellows is found in all the states east of the Mississippi and north of the northern boundaries of Tennessee and North Carolina, excepting Wisconsin and possibly some of the northern New



1 HEALTHY PEACH. 2 2. YELLOWS PEACH.

Appearance of healthy and diseased peaches.
(After Smith, Bull. 9, Sec. Veg. Path. U. S. Dept. of Agriculture.)

England states. It is widespread in Delaware[7], Maryland, New Jersey, New York, Connecticut, Michigan, Pennsylvania, and as we have seen, in Ohio also. Yellows is not known in the states south of Virginia and Kentucky, but in parts of these another disease called peach rosette is found. The writer has not met with peach rosette in Ohio, nor has he learned of its occurrence.

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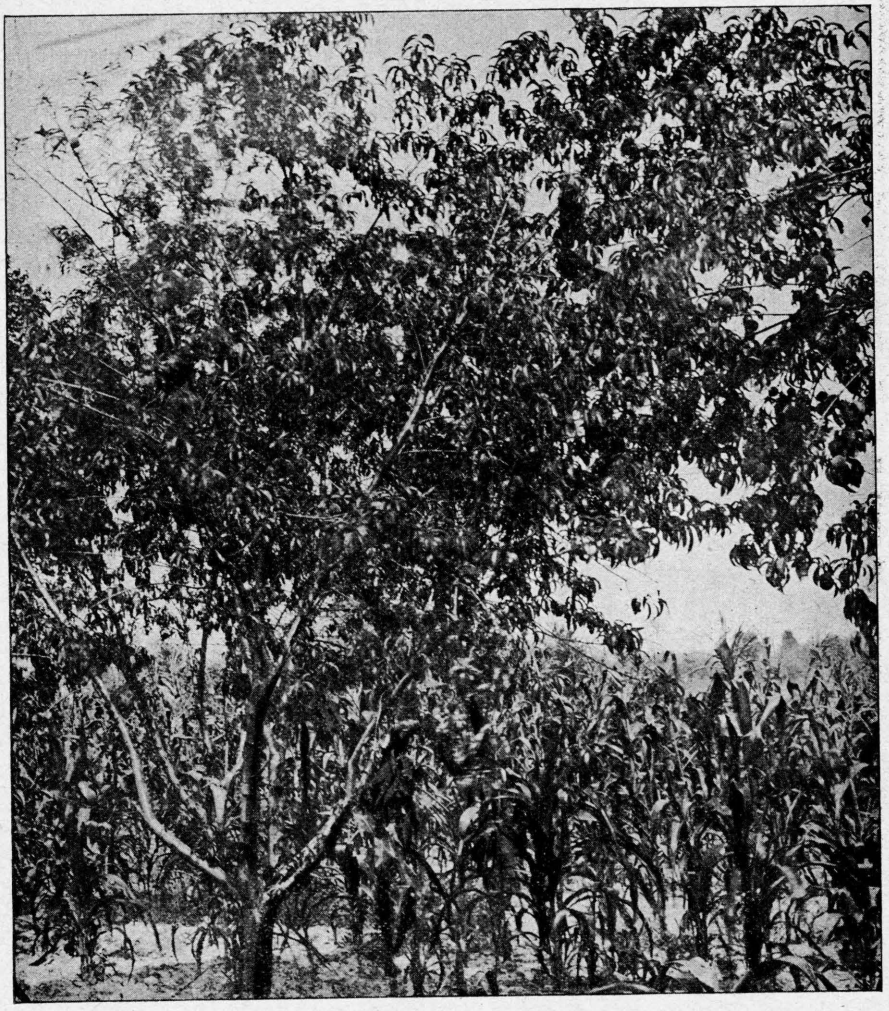
[6]Smith, E F., Bulletin 9, Sect. Veg. Pathol., U. S. Dept. Agric., 1888, pp. 17-20
[7]Smith, E. F., Farmers' Bulletin No. 17, U. S. Dept. Agric., 1894, p. 6.

PLATE I.



An early stage of yellows. The branch to the left is affected. (From a photograph, 1895.*)

*All the photographs referred to in this bulletin are by the writer.

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SYMPTOMS OF YELLOWS.

While a specific cause for yellows cannot be assigned, the symptoms may be readily learned and recognized. They are: 1. Premature ripening of the fruit, which is highly colored and spotted and has the flesh marbled with red. 2. Premature unfolding of winter buds. The early unfolding may extend to blossom buds as well as to leaf buds. Opening leaf buds have been observed as early as June and as late as November; prematurity in spring is much less common. This symptom is conspicu-

FIG. 5. Winter buds unfolding in autumn.
(After Smith, Farmers' Bulletin No. 17, U. S. Department of Agriculture.)

ous in yellows trees during August, September and October. 3. Besides the prematurity in opening of buds, new buds or resting buds develop on the trunk and branches and grow into slender, sickly looking shoots.

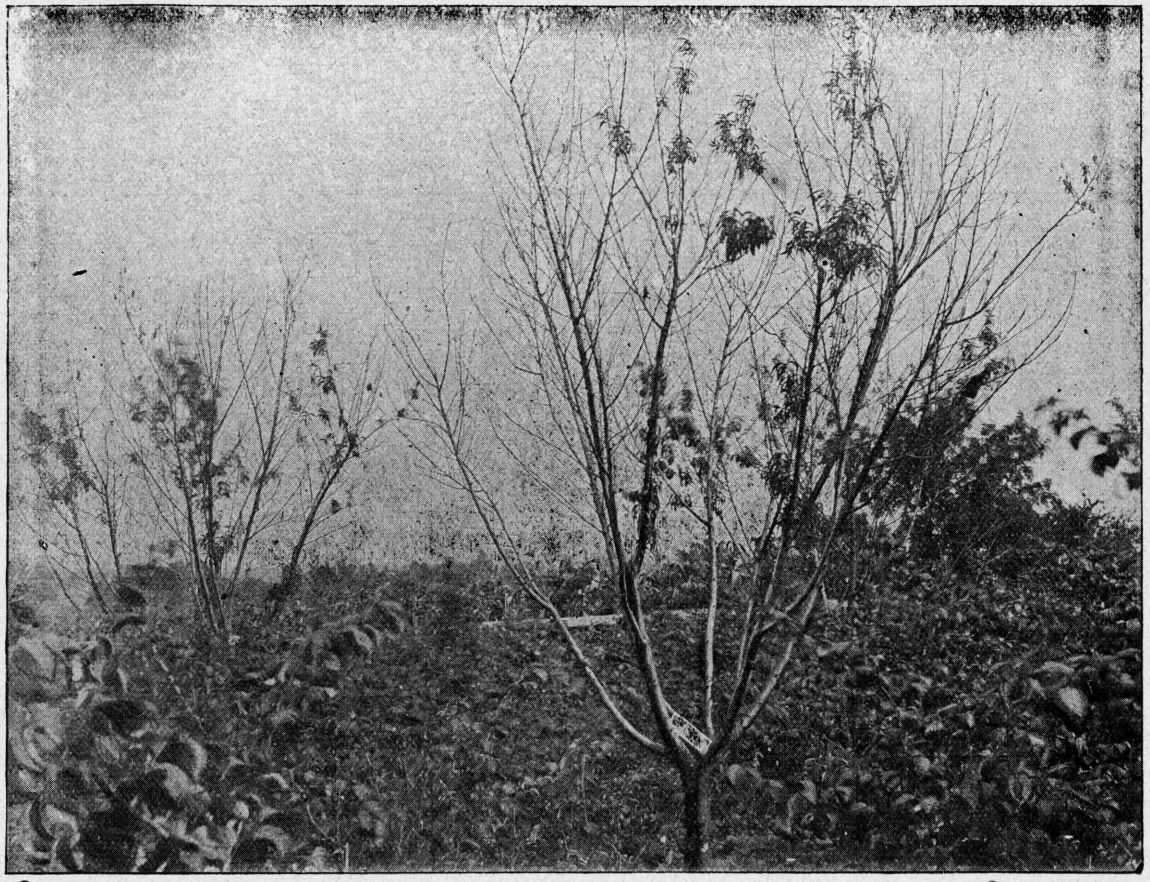
The yellows fruit may ripen one to six weeks in advance of the normal period. The spotted coloring with red is very evident upon the outside of the peach; it extends as red marbling from skin to stone. The external appearance is shown in Fig. 4. In yellows peaches, oblique slices from the colored side will show the red-marbling of the flesh. The

fruit is deficient in quality, being insipid or mawkish. In bearing trees the premature ripening of fruit is commonly the first symptom. This may occur upon but a single branch, as is rather poorly shown in plate I. But when a single portion of the tree shows these symptoms the whole tree is hopelessly diseased, and should be treated as others that are affected. Premature, red spotted fruit is of itself conclusive evidence of yellows. The size and character of the fruit will vary with the stage of the disease in the tree bearing it. In first year cases the fruit is good sized, while in the second and third years it may be very small. Yellows peaches are distinguishable wherever seen. The enforcement of state requirements against such affected peaches seems entirely practicable.

Premature development of buds upon yellows trees is also characteristic. It is easily seen in late summer and throughout the fall. Fig. 5 shows this autumnal unfolding of buds. The blossoms which open are normal in form. Free blooming of yellows trees may occur as late as November. It is less frequent than the unfolding of leaf buds in the autumn. The branches from prematurely developed buds or from resting buds show many characteristic forms of growth. The primary shoot may branch again and again, to produce "broom growths" of slender, wiry twigs. In third and fourth year cases of yellows, the "bunchy," broom growth effect is very striking. Plate II shows this feature very well. All these twigs are slender and wiry, the leaves yellow in color, narrow and long and the whole appearance feeble and debilitated.

In the first and second year cases of yellows, the shoots from adventitious or resting buds on the trunk and larger branches are quite characteristic. These are often the first clear indication of yellows, especially in trees not bearing. The leaves upon these shoots are long and narrow, yellow in color and often the larger "water sprouts" develop broom-like clusters of branches at the top while normal below. In trees that have not yet come into bearing the growing of hidden buds or new buds on the trunk and larger branches is often the only safe indication of yellows. In some trees of this age the second class of symptoms holds good, but by no means generally.

Indeed for practical judging of yellows trees all three symptoms are equally diagnostic. Any one of them, clearly developed, is conclusive evidence to one familiar with the symptoms. Circumstances of the time and period will determine which one is most to be employed. It must be borne in mind that general yellow color is not a characteristic symptom of yellows. The particular symptoms enumerated may always be relied upon. The person without experience in distinguishing yellows must lay aside the color notion and use that of special peculiarities in growth and development. Yellow color of peach foliage indicates more commonly some lack of vigor in the tree, and in such cases we may often find the true explanation in wet feet or in the attacks the borer at the root.



Advanced stage of yellows in peach trees among raspberries. Berlin Heights, O., August, 1895.
(From a photograph.)

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A further caution is needed. In sandy soils, especially, trees transplanted from one to three years often make very slight growth, and develop very slender branches. The leaves are more nearly normal and there is an absence of premature growth. With trees showing these characters it is well to examine the roots for the root aphis or root louse. This is a small, black aphis, resembling the one found upon cherry trees. The lice themselves may be seen frequently upon the peach leaves, accompanied by ants. The ants and lice apparently live as messmates. The remedy, where the aphis is found upon the roots, will lie in the destruction of the insects rather than of the tree as for yellows. The leaves of peach trees curl up, turn yellow and drop. This has been mistaken for yellows. It is in fact leaf curl, a fungous disease, illustrated upon page 225.

THE CAUSE AND SPREAD OF YELLOWS

Yellows is a contagious disease. It is spread from one diseased tree to another. Our authority upon peach yellows, Dr. E. F. Smith, concludes that it is a physiological disease, somewhat analogous to variegation in plants.[8] There appears to be no specific germ of the disease, but it is unquestionably spread by bud inoculation and by proximity of affected trees. While the cause is yet undetermined, the manner of spread, is, for practical purposes, well demonstrated. If yellows trees are permitted to live in a district the disease spreads to other trees, though not necessarily to the adjacent ones first. In many instances the secondary cases are scattered irregularly about in the orchard. Not only is there danger from living trees, but also from those cut down. Cases are cited where yellows was spread by dragging uprooted, diseased trees through the orchard. Safety is consequently not attained by cutting and piling the yellows trees.

When yellows comes into a district previously exempt, upon young trees brought from outside, the nursery is to be suspected. Undoubtedly yellows has been spread from some of the nurseries. Buds from affected trees may also be the means of spreading the trouble. Both sources of danger, namely, diseased buds and living yellows trees, are present in proportion to the prevalence of the disease in a given region. The exercise of caution in the purchase of stock is therefore needed. The official inspection of nursery premises is of value. Reliability and responsibility in the grower of nursery stock is of greatest value in all such protection. The use of Tennessee or Ozark seeds is general among growers of peach trees. The danger from diseased pits appears small in any event, because of lack of germinating power when the trees which bore them are diseased.

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[8] Loc. cit, p. 10.

But it is useless to protect by nursery inspection while in any district countless seedling trees along the highways are affected with yellows. That such yellows trees are left by the roadside has been verified by actual observation in three different counties. The danger from yellows increases in proportion to the time during which trees are permitted to remain undestroyed. One instance under observation supports the view that yellows is spread by men, team and tools. A new orchard became affected near the entrance only.

DAMAGE CAUSED BY YELLOWS.

The losses from yellows in Ohio have not yet been excessive. In Erie, Lake and Sandusky counties they have been greater than in most others up to present writing, but conditions are now likely to be reversed somewhat. The larger centers of production begin to show the greater losses.

All trees once attacked by yellows die in from two to six years. Cutting off the branches first affected will not prevent the course of the disease and the final destruction of the tree. The damage will therefore depend directly upon the exposure to infection. All peach orchards are liable to be swept away in any district where yellows is neglected. Yet where yellows is carefully and promptly dealt with the losses are not likely to be great. This judgment is based upon the apparent spread during three seasons only. A period of greater virulence might modify it greatly. The annual losses or damages from yellows in the state may not exceed those at present caused by the peach borer. But in estimating the damages of this disease, the necessity for promptness in preventive measures is always to be emphasized.

PREVENTION AND CONTROL OF YELLOWS.

All efficient measures to control the yellows have thus far been preventive solely. The application of fungicides in sprays would not seem to have reason for trial. Experiments with fertilizers to cure yellows have proven of no avail. The contagion and spread being as stated, the suggested remedy lies in removing the source of contagion. Practice has shown the efficiency of the method.

Yellows is prevented, then, by the removal of all yellow strees, root and branch, and their subsequent destruction by fire. The chief object of removal is that the yellows trees may be burned. Removal itself has only an undetermined efficiency; removal and burning of yellows trees prevents its spread in proportion to the extermination of contagion. To be efficient the measures need to be prompt and to be repeated each year, the burning to be done near the point of removal. This practice has been inaugurated in the older yellows districts of Erie and Sandusky counties. The fruit commissioners report fewer cases to remove each year. The writer recommends the prompt pulling out and burning of

affected trees and replanting the following spring to keep the stand of the orchard and thus insure proper attention to it, if for no other reason. Michigan experience in this line has been satisfactory, growers reporting a rather less tendency in the replants to suffer from yellows than is manifest in the adjacent trees. Pruning tools have not been proven dangerous in diseased orchards. The tools may be sterilized in suspicious cases by dipping in a 1 to 1000 solution of corrosive sublimate or in a solution of carbolic acid. Bordeaux mixture will corrode the tools.

Successful control depends upon promptness and thoroughness in the removal and burning of yellows trees. The present Ohio statute upon yellows, black-knot and San José scale is being enforced and beneficial results in the suppression of yellows are being reported. The statute was printed in an earlier bulletin, (Bulletin 72.)

2. ROSETTE.

It has already been stated that rosette of the peach occurs in Georgia and parts of South Carolina and Kansas. This disease is similar in certain respects to yellows, but unlike it has a shorter course and different symptoms. Like yellows it may first attack one part of a tree and then the remainder, but it more commonly attacks the whole tree.[9]

The symptoms commonly develop in spring and the trees attacked always die the following fall or winter. In trees with rosette, the leaf buds all grow into compact tufts or rosettes. The rosettes, although but two or three inches long, often contain several hundred leaves. From Smith's account we learn that the color is generally yellowish green, and that the older leaves at the base of the tufts are frequently quite long, but have inrolled margins and a peculiar, stiff appearance, being straighter than healthy leaves. They turn yellow and drop in early summer while the inner leaves are yet green. The compact bunching of the leaves is in marked contrast to yellows. In severe cases no fruit is matured. The contrast of an "acute attack (rosette) to a chronic ailment (yellows)" is made clear.

Some peculiar shoots of the peach, wherein the internodes between leaves are very short and the leaves very long and narrow, as well as some other leaf clusters infested by ants, have been referred to me with the inquiry as to whether or not the trouble might be rosette. The cause of the abnormal shoots is still unexplained; they lack the shorter inner leaves of rosette. Until demonstrated to exist in Ohio, growers may take some consolation in the improbability of its occurrence here.

3. A TWIG DISEASE WITH GUM-FLOW.

During the past two years specimens of peach branches affected as are those in plate III, have been sent to the Station, and during the

[9]Smith, E. F., loc., cit. pp. 14-16.

winter of 1896-7 these came with increased frequency. Field and laboratory studies of this trouble have been carried on for the past year.

Briefly, the symptoms of the disease may be stated as the exudation of gum upon the twigs, branches and even upon the trunks of the trees. There are no obvious perforations of the bark, as when attacked by the fruit bark beetle, Scolytus. Where this beetle has eaten into the bark the shot-hole perforations will be found. The exuding gum hardens and becomes conspicuous (Figs. 6 & 7.) The trouble prevails at all seasons, but is most manifest when the leaves are off the tree; perhaps this is aided by the increased gum-flow during late winter. Upon the young growth, the gum is found near the leaf scars of the previous season; in general the exudation occurs at these points (Figs. 1 & 2, Pl. III) Following the continued exudation of gum enlargements come at many of the affected points. In certain cases, by no means infrequent, the enlargements from this cause are so conspicuous as to lead them to be mistaken for black-knot. This disease of the peach is widely scattered in the state, and is known to occur in Athens, Miami, Geauga, Highland, Ottawa, Sandusky and Wayne counties. In Highland county, near Leesburg, there is an orchard that has been affected in this manner for about four years. It was first observed upon trees of the Heath variety, growing along the west side of the orchard and next the highway. Thence the trouble spread to adjacent trees and at the time of my first visit, in July, 1896, it had involved most of the trees in the orchard. Many of the branches were greatly enlarged, after the manner shown (Pl. III.) The orchard had been cultivated for two years and then seeded down.

An orchard near Clyde, Sandusky county, has been similarly affected for five years past. In it the first tree to become diseased, the one photographed for Fig. 6, was growing next the road. From this tree the gum-flow spread to the surrounding ones and thence to the whole orchard which lies north of the tree mentioned. The trees are chiefly of the Smock variety; the orchard was not cultivated. Progressive spread appears to have occurred in both of the cases cited.

A small orchard of one-year-old Elberta peach trees, a half mile nearer Clyde than those just described, was found to be diseased in this same manner. The first observation was made by Mr. H. L. Persing, who sent me specimens about December 15, 1896. Only a few of the southwest trees showed the symptoms, while others to the north and east were yet apparently healthy. All were set from the same lot. No connection is inferred between these and the other diseased trees near Clyde.

At Gypsum, Ottawa county, two year old peach trees, set between the vines of an old vineyard, were badly covered with gum. (See Fig. 7.) Plum trees at Marblehead, in the same county, also planted in an old vineyard, suffered in a similar manner. (See Bulletin 79.) In addition to these, occasional young replants in peach orchards about Gypsum are

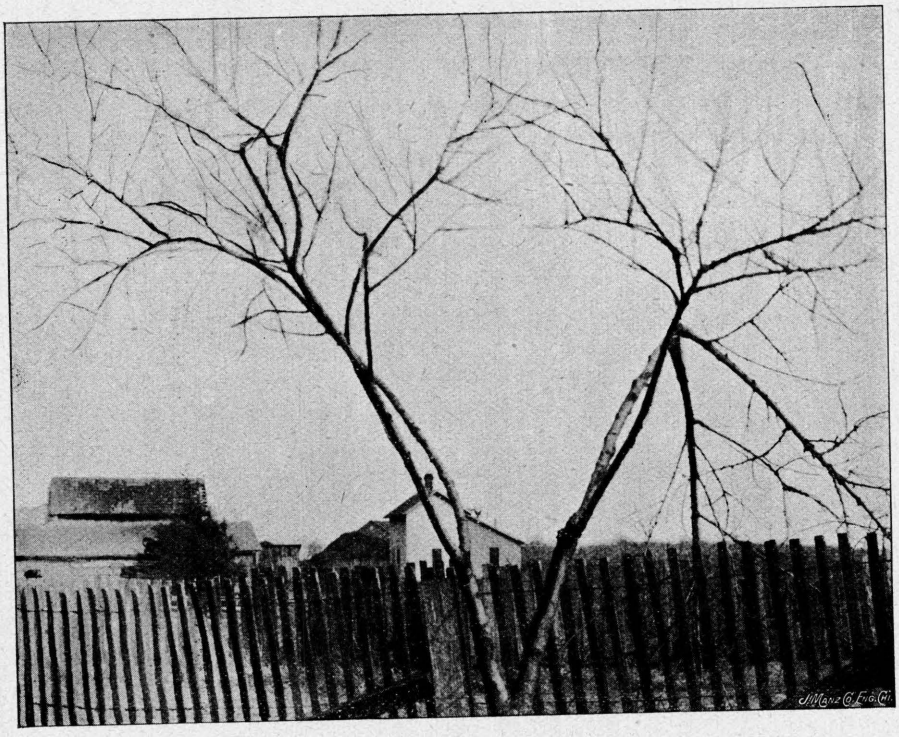


FIG. 6.—Peach tree with gum-flow, Clyde, O.
(From a photograph, 1897.)

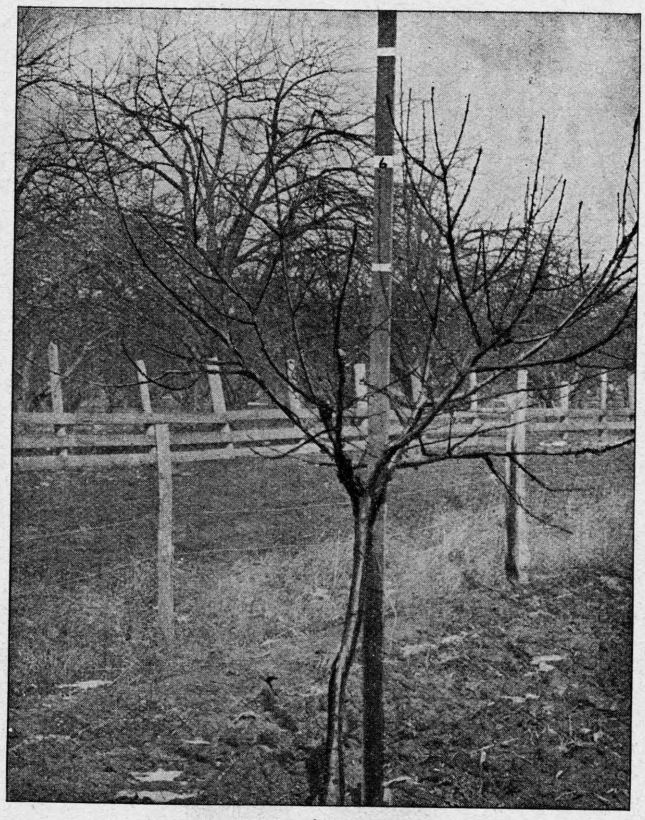


FIG. 7.—Two year old peach tree with gum-flow, Gypsum, O.
(From a photograph, 1897.)

affected in this way. It will thus seem that the apparent advance of the gum-flow symptoms justly causes anxiety. The fruitfulness of the trees is also impaired and much of the fruit is worthless because of gum pockets in it and the exuded gum upon its surface. At present it cannot be stated that the trees are very soon destroyed, although the profits from them must be much reduced. The ultimate effect must be to shorten the life of the diseased trees.

NATURE OF THIS TWIG DISEASE.

It has been stated already that gum-flow is a conspicuous symptom of the twig disease we have been describing. Yet it does not seem proper to name the diseased condition from this symptom, evidently a result of the disease rather than its cause. I have not used the term "gummosis," which has been suggested for a similar disease of the plum, because of this apparent impropriety.

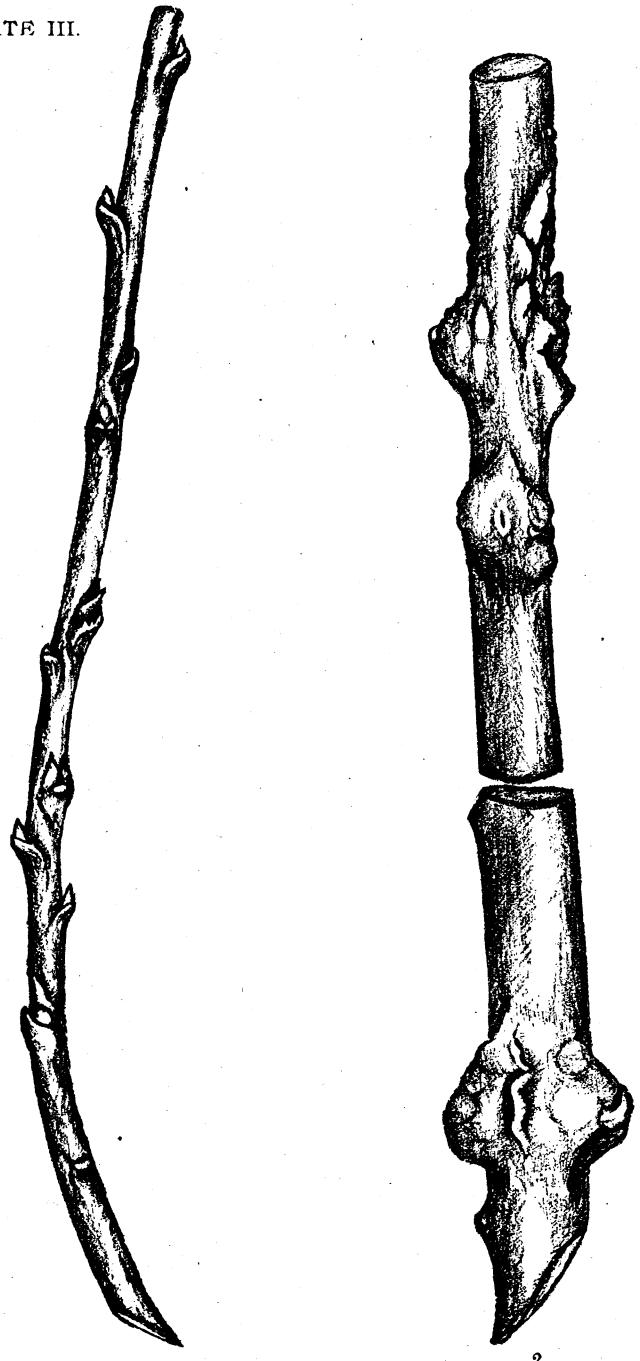
Sectional examination of the diseased branches, in many cases shows a dead or injured area. In fact this area is so generally found that it may be taken as universal. In the region of the dead or injured area we find gum pockets and they continue, apparently, while growth lasts. So it is inferred that the gum-flow in larger branches usually represents a dead or injured area of the young growth. This inference, however, is but tentative, although no apparent exceptions have been met with. Plate III may help to make plain the appearance of affected parts. Upon the growth of the season the buds have been destroyed in places and there are dead areas in the leaf axils or beside the leaf scars. The condition here represented was found from June to December and later. The other figure shows the enlargements before mentioned. The swellings were preceded by similar gum exudations to those in Figures 6 and 7.

From the studies made I am inclined to regard the later symptoms of excessive gum-flow, enlargement and the like, as the consequences of such injuries as are represented in Fig. 1, Plate III. Given, such areas of dead tissue, the exudation of gum, to a certain extent, would follow, and perhaps, likewise the continued irritation and enlargement. But aside from the first year injuries about the region of the bud, there appear to be further disturbances of the plant. The wound having been covered for a time we might expect a diminished exudation of gum. This does not seem to occur and the reappearance of old conditions seems to show a serious disorganization in the tree, especially in respect to gum production.

In Europe such diseases are frequent. At present writing I have met with no American references to such conditions as these described. Dr. Frank[10] devotes six pages to the discussion and illustration of what is called "Gum-flow of stone fruit trees" (Gummifluss der Steinobst-

[10]Die Krankheiten der Pflanzen, I, 51–56.

PLATE III.



1. 2.

Twig disease of peach with gum-flow. Fig. 1, shows the appearance of previous year's growth on which a part of the buds have been destroyed and gum has exuded slightly. Fig. 2 shows later stages with great enlargement of branch and copious flow of gum. (From drawing by Mrs. Selby.)

bäume). Other references in foreign works are frequent. In the case under discussion Frank concludes that the gum-flow is but a symptom of some different disease which can only be cured by preventing the conditions which called it forth. Similar diseases of the plum and cherry are included in the reference just cited.

Gum-flow or gum disease exists in other fruits. The "*male della gomma*,"[12] as it is called in Italy, affects citrus fruits, orange and lemon trees and the like. There is a root disease of the fig, *Il Marciume del Fico*,[13] showing similar gum formation, an analogous disease of the mulberry in Italy, *Bacteriosi del gelso*,"[14] and in several countries of Europe a gum disease of the vine which has latterly been called, "*La gommose bacillaire de la vigne* by Prillieux and Delacroix, these ascribing it to bacterial action. We may conclude that this trouble of the peach, manifested by copious gum-flow upon the twigs and branches, belongs to an obscure and imperfectly understood class of diseases. And further, that the trouble is liable to increase with the prolonged culture of susceptible fruit trees in America.

HYPOTHESES AS TO THE CAUSE OF THE DISEASE.

The various hypotheses enumerated below are advanced as to the cause of this so-called gum disease. From these we must exclude the obvious wounds or other injuries as by insects, etc. :

1. On cherry trees, transplanting in too strong a soil. (Duhamel)
2. The gum disease is due to a fungus, *Coryneum Beyerinckii* Oude. (Oudeman)
3. Caused in peach by an insect which works about the base of the leaf. (An Ohio correspondent)
4. Caused indirectly by hard, undrained clay soil, which is unfavorable to the tree. (Frank)
5. Due to bacteria which begin the injury.
6. Due to atmospheric conditions, such as frost injury, excessive rainfall, etc.
7. Caused by root galls.
8. Caused by any unfavorable conditions which may reduce the life vigor of the plant. (Frank)
9. In the fruit, is a common condition upon peach trees attacked by rosette. (Smith)

Of these the first and second appear to be disproved and the third fails of proof. The fourth, seventh, eighth and ninth conform to observed facts. The fifth was to the writer a probable hypothesis, but

[11] Loc. cit. p. 56.

[12] and [13] Frank, loc. cit., p. 58, 59.

[14] Abt. Cent. für Bact. u. Parasitenk. III, 10, 60 (Peglion.)

several efforts to secure cultures are without satisfactory result. The claims for a bacterial origin of the vine gummosis, and for that of the mulberry are yet questioned. While holding in abeyance any judgment as to the possible organism concerned, the claims of those who would find in this trouble a manifestation or symptom of some impairment of vigor or interference with normal life activities seem to afford a partial if not a complete explanation of cause.

While dealing with the illustrated gum-flow, mention should be made of a case not clearly of this sort. In one large orchard of Ottawa county a single variety, Red Cheek Melocoton, suffers from a gum disease (?) of branches and fruit. There appear the same dead areas under gummy spots and yet there seems to be no serious impairment of the trees. As the foreman put it "the trees appear to bear as many and as pretty peaches, besides the gum." Oldmixon on one side of this block and Early Rivers on the other have no indication of the gum disease. If a weakness exists it is here apparently in the variety. In spite of the good appearance of the peaches from these trees they are full of gum pockets and have the quality impaired. This gummosis of the fruit is general upon all varieties of peaches from trees affected by the disease before described.

REMEDIES.

A progressive nature of the trouble is indicated by the observation at Leesburg and Clyde. This points to destruction of affected trees where but a small number are diseased. If this be only symptomatic, an effort toward remedy by drainage, tillage and the like, is indicated. For orchards, close pruning and spraying seem worthy of trial. The uselessness and danger even of permitting unfruitful trees to stand indefinitely, need not be restated. When trees are hopelessly diseased their early destruction is advised.

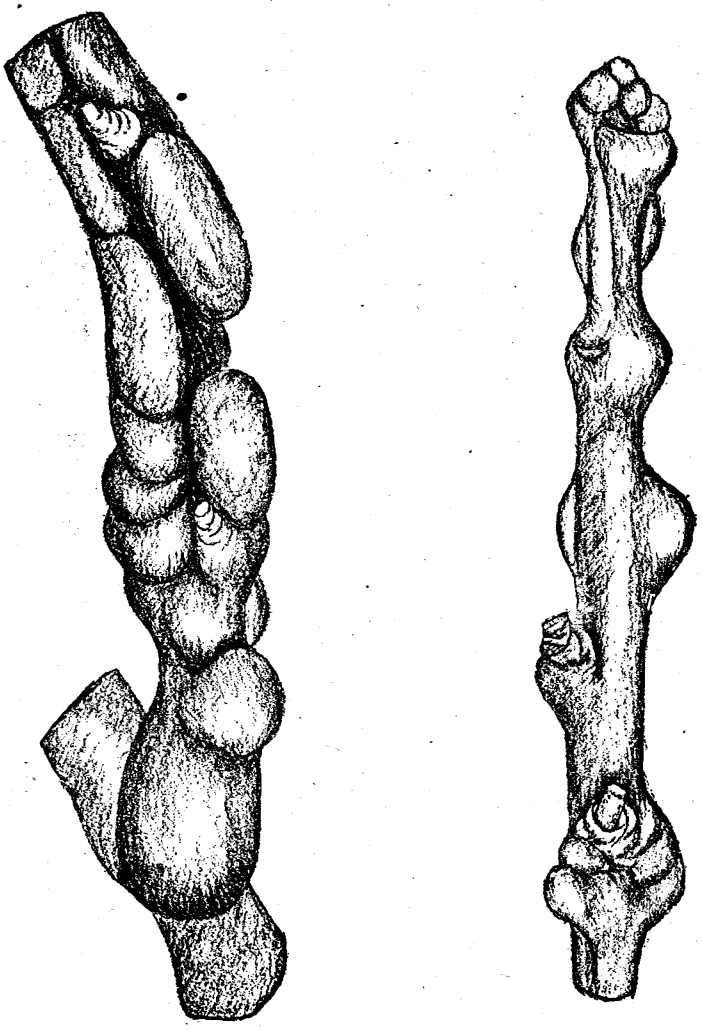
4. DROPSICAL SWELLINGS OF TWIGS AND BRANCHES.

The illustrations in Plate IV show the appearance of twig tip and branch (not more than two years old) from a three year old peach tree. These were sent me by a grower of Ottawa county, who met with them in pruning. The condition was confined to a single branch. Similar, single swellings were found upon other trees not far away. No flow of gum appeared upon this or other trees. Upon sectioning the enlargements a layer of a sixteenth inch or more in thickness situated just beneath the epidermis, was found to be soft and spongy, Conforming to the general shape was the woody tissue in which several pockets or more or less open spongy masses occurred. The appearance suggests a resemblance to the dropsy[15] of golden currant, *Ribes aureum.*

In nature this dropsy may approach the disease with flow of gum.

[15] Frank, loc. cit. III, 314 (1896). He cites Sorauer Pflanzenk. — 2, I. 233.

PLATE IV.



2. 1.

Dropsical swellings of peach branches. Fig. 1, shows the tip of new growth with its enlargements. Fig. 2, the lower portion of the branch. Both taken in winter. (From drawing by Mrs. Selby.)

Pruning off dropsical parts and attention to favorable conditions of growth are suggested as remedial measures.

5. TWIG SPOTS—BROWNING OF GREEN BARK.

In uncultivated orchards spotting of twigs is frequent. Many specimens show definite spots in which the epidermis has turned brown, much like the appearance of anthracnose spots on raspberry canes, while the living layers still survive. In one orchard, especially, this condition appeared serious for a time. It disappeared after spraying and cultivation were begun. Such spotting is very general. It was very marked upon the green twigs of some nursery trees of the Summer Snow variety which were purchased for experiment. It is regarded as symptomatic merely. No fungus or other organism has been found to occur constantly in the spots and the practice of cultivation and good care with the orchards cause much of it to disappear. It is thought that these practices will measurably control the symptoms named.

A normal cork growth is often mistaken for a fungus or for a diseased condition. If the young twigs are observed, small spots of the green outer bark will be seen to turn brown. This occurs usually about a breathing pore or stomate, Later, a small roughened elevation of corky bark appears. While in some instances the spots may not be essentially normal, the corky growth, first in small elevations, and then in larger ones seems to be perfectly normal and characteristic of the class to which the peach belongs—an anatomical feature which is constant.

6. CROWN GALL OF THE PEACH.

This disease manifests itself in enlargements upon the roots and stem of the peach tree but with a decided tendency to occur at the crown of the plant. See plates V and VI. The root galls of the raspberry, blackberry, pear and apple have been treated of in another bulletin.[16]

As stated therein, the disease is thought to be the same as that for which Woodworth[17] proposed the name "crown gall" or "crown knot," himself earlier using the former and later the latter name. It has been studied in Arizona by Tuomey[18] who follows the name of crown knot. Dr. E. F. Smith[19] has treated of these excrescences under the general title "stem and root tumors" but uses the name "crown gall" in the plate description. The disease appears to be the same as the Wurzelkropfe of the Germans.[20] The quite general restriction of the term gall to excrescences resulting from insect irritation does not appear a serious objection to its use in this manner. The localization of the trouble by the name crown gall has a significance that will be generally recognized, though

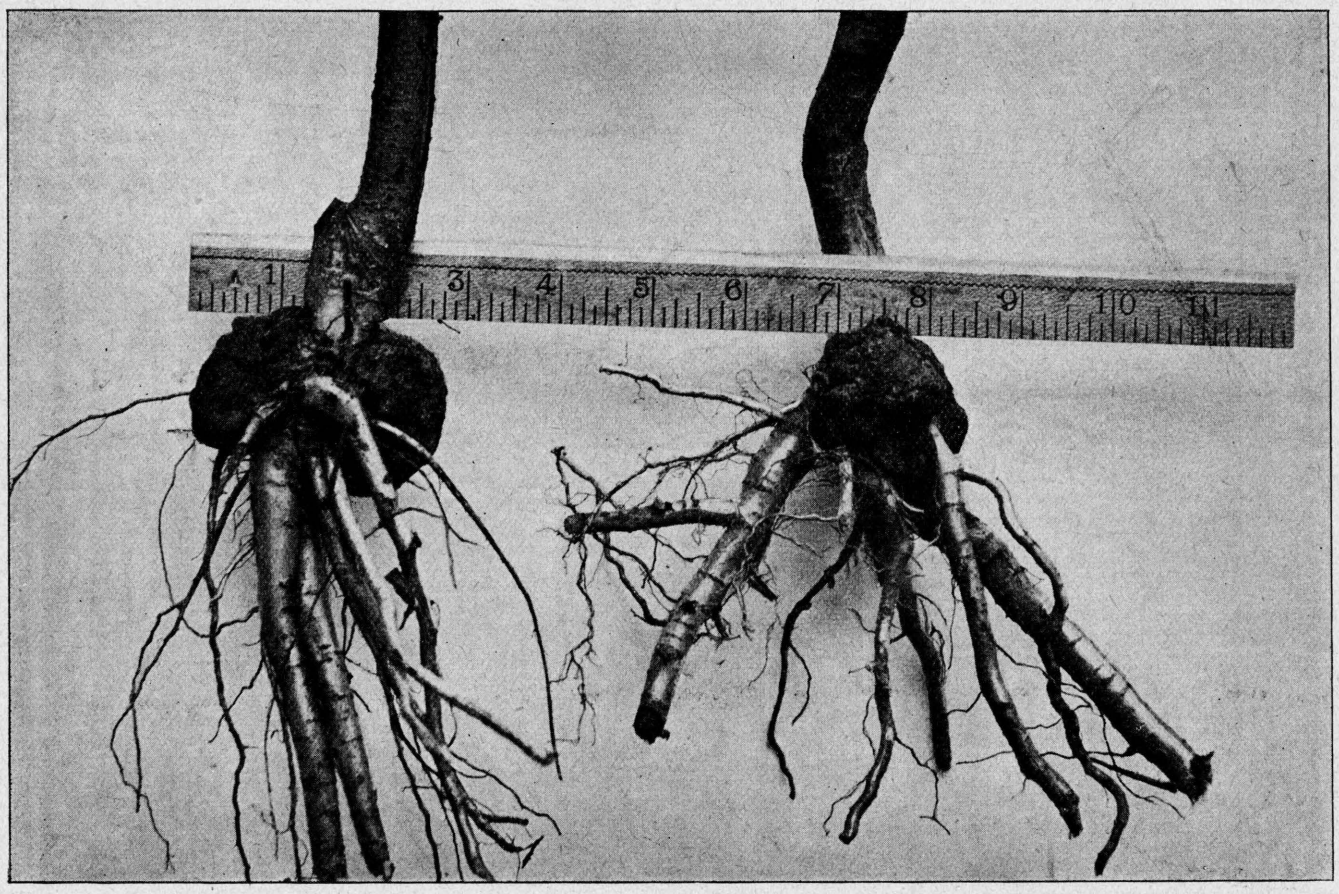
[16] Bulletin **79**, 108-120, 127, 139.

[17] Bulletin California Expt. Sta. **99** (1892). See also Annual Reports Cal. Expt. Sta., 1892-4, 436, and 1894-5, 231.

[18] Bul. Ariz. Exp. Sta. (II) **1**, (1894)

[19] Jour. Myc., VII, 376. (1894)

[20] Frank loc. cit. III, 318 who quotes Sorauer Pflauzenk. I ,740.
See also Bulletins Expt. Station of Cornell Universsity **74**, 318; **117**, 367.



Crown gall of the peach. These two trees were offered for delivery in stock purchased. They show the "crown" development of the galls. (From a photograph, 1897.)

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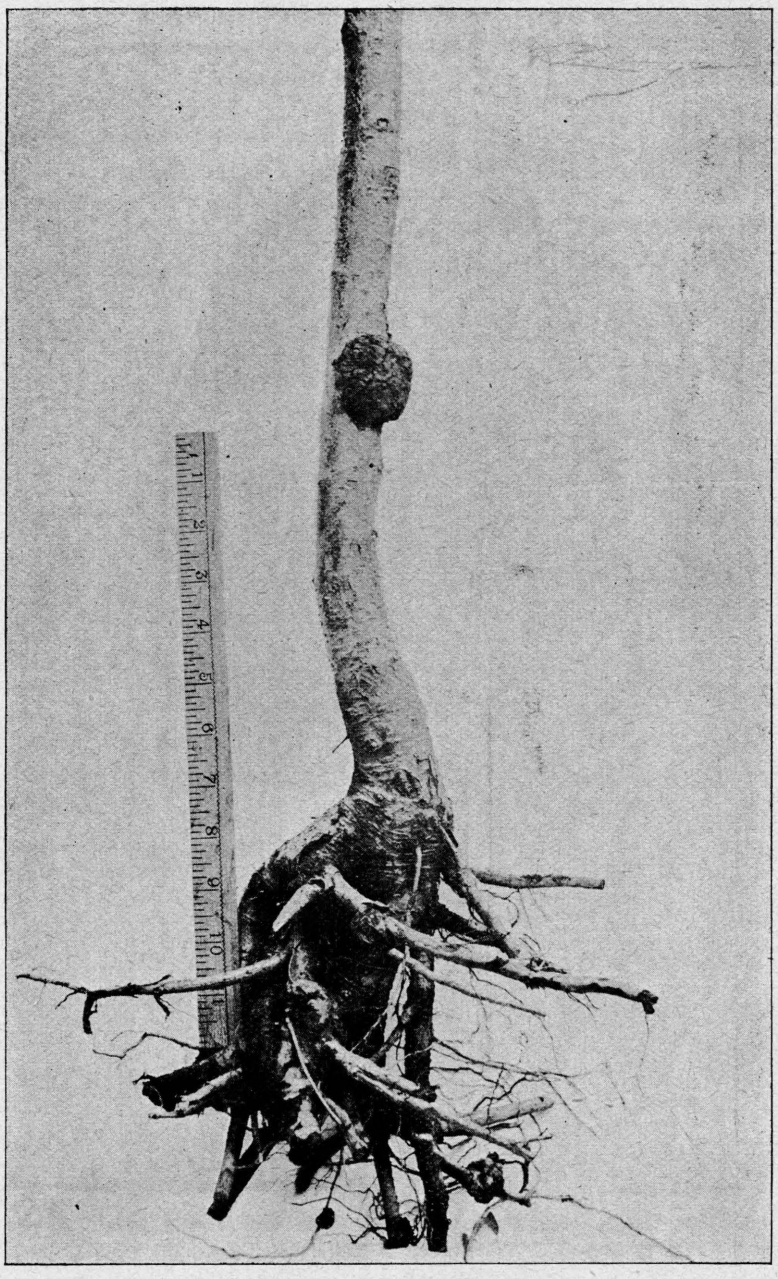
PLATE VI.



Crown gall of the peach with development of enlargement on stem above ground, associated with galls below. A three year old tree from orchard of Mr. Geo. A. Beebe, Lakeside, O. (From a photograph, 1897.)

as shown in the illustrations, the trouble is not restricted to the crown of the peach tree This name is therefore used for the trouble in question. Excepting possibly the raspberry, the peach, of all fruit growths, appears to be most frequently attacked by crown gall in Ohio, at present. However, the larger portion of the peach trees that have been affected with these galls came from without the state, notably from the east and south. They were upon nursery stock for planting.

The nature and cause of crown gall, especially the matter of cause, do not admit of precise statement. In nature of growth these galls are usually soft, corky or spongy growths upon the various parts of the tree specified. Below ground they are renewed on the peach with each season's growth, the old galls falling away and decaying while new ones are formed. There appears to be an occasional exception in half-gall half-knot growths upon the trees near the surface of the earth, which may persist for more than one season, but in general the character stated holds true on the peach. As often as an old gall dies off new ones appear upon adjacent or other parts of the tree affected. When new the galls are externally of the same color as healthy roots. This continued formation of excrescences continues until the death of the tree, which usually occurs in from one to three years after the first appearance of the galls. So far as the pathological effects are concerned, the death of the tree is apparently more often caused by cutting off the water supply. However, that this is the case may not always be clear nor indeed be true.

After the galls once begin to be formed there is a manifest tendency in roots and stems to gall formation. I have never met with cases in which the stem galls, shown in plate VI, were produced except in conjunction with galls upon root and crown; the same holds true in the disease as it affects the raspberry. In this respect it shows a cancerous nature. I do not recall a single instance ont of the many observed and recorded, in which the tree surviving transplanting, the removal of the galls by excision served to prevent the formation of new galls upon the same tree. Excision appeared to exert no influence whatever in the way of suppressing the trouble, and this irrespective of the location of the excised galls; whether but a single gall upon a small root or more than one gall on stem or root or both were removed and the wounds rubbed with sulfur, the new galls constantly appeared later. This may be taken as showing a diseased tendency of the plant tissues and this condition, this diathesis as it may be called, can scarcely contribute to the longevity of the tree independent of cutting off the water supply. Moreover, the disease is apparently communicable over short distances in the soil. Twenty-five per cent. (1 of 4) healthy peach trees, transplanted in each case within about eight inches of a diseased peach tree of same age, became affected during the first two seasons, while none of the healthy trees transplanted at the same time in the same soil, a piece of sod not before in orchard trees, at the usual orchard distances, became affected

with the galls in that time. Out of twenty-five healtny peach trees, set in a badly galled plantation of Thompson's Prolific raspberry at Berlin Heights,[21] Erie county, sixteen per cent. of those surviving (a few were killed by poisons applied about the roots) were affected with the peach crown and root galls at the end of the second season. To be sure, the cases of peaches affected by proximity to diseased trees in fresh land are not numerous enough to be final proof, but the trees which became affected from transplanting into diseased raspberry lot were in sufficient number. In opening bundles of diseased trees we have usually found that several trees with the crown gall were together, as if gathered from adjacent positions in the nursery row.

A prominent grower of nursery stock recounts an experience in the same line. About 1893 a part of a block of apple trees were found, when dug, to be affected with crown gall. They were followed by a year's rest of the land in grain and grass and then by peach trees, seeds being drilled in fall. In that portion where the apple trees had been diseased, most of the peach trees were likewise affected with the crown gall and were worthless. In so far as present light enables one to judge, the conclusion that crown gall is a contagious disease appears to be warranted. Upon the Pacific slope Woodworth has frequently stated the contagious nature of the disease and in New Jersey, Halsted[22] has inoculated seedlings of the peach by means of minced galls from the peach in the earth used; no result was obtained by the use of the minced raspberry galls in the soil. This malady is one of the most important that affects the Ohio peach grower, and a right understanding of its nature becomes very desirable. There are, further, many evidences of the decided increase of the crown gall disease and an extension of the number of hosts affected.

CAUSE OF CROWN GALL.

The manifestations of this trouble having been observed, one is led directly to seek the cause of the disease in question. Here the matter is difficult, since the affected parts are almost entirely beneath the soil or near its surface. The contagious nature asserted for the disease indicates a parasitic origin, and such an hypothesis of cause seems to be held most commonly by those who have studied the galls. Smith[23] suggested an external irritant and advised seeking "external parasites, especially animal organisms." Halsted[24] has recently reported the occurrence of a fungus upon these galls of the peach, but without claiming for it a causal relation. The fungus in question agrees somewhat in

[21] See Bulletin 79.

[22] Report of the Botanist N. J. Agrl. Coll. Expt. Station, 1896, 413-14.

[23] Loc. Cit., p. 376.

[24] Bulletin Torrey Bot. Club, XXIV, 509.

characters with Chalara and Ceratocystis, the fungi of pineapple mold and sweet potato black rot respectively. The writer[25] has suggested a causal relation between eelworms or nematodes and these crown galls of the raspberry. The apparent communicability of the raspberry trouble to the peach may indicate a like cause for the galls on these two plants. A case coming under the writer's observation bears upon the point. A small lot of peach trees, in a gentleman's garden in Ottawa county were found to be badly affected with crown gall in certain spots. These trees were transplanted orchard volunteers of small size and moderate vigor. All had been budded in the fall of 1896, and some trees had died, presumably from the galls, before they were first examined, July 9, 1897. The diseased trees were chiefly in two of the three rows of trees and very few or none at all in the other; the proportion of diseased trees was also greater at the north end of the rows and in the lower areas of the field. About the roots of these diseased trees, in several cases, masses of partly decayed organic matter were found. It developed upon inquiry that a heavy application of dried, lumpy manure from a cow stable had been applied two years before the trees were set, which, however, had covered only a part of the ground in trees and evidently from the organic matter found, included the soil of the two badly affected rows of peach trees. Microscopic examination of the galls, when the laboratory was reached, showed numerous nematodes in the peripheral regions of the galls, though the worms were rather less abundant than on the galls of the raspberry to which reference has been made. It would seem that the parts of this soil on which the trees were most diseased, nearly 50 per cent. of them in the north portion of the lot, was adapted to the work of these animal parasites. The nematodes apparently referable to Heterodera, are the only organism that I have as yet been able to detect with reasonable uniformity in conjunction with the crown galls. They are accordingly looked upon as a probable agency in the production of the galls of the peach.

It must be admitted, however, that some facts are adverse to the nematode hypothesis of the cause of crown gall. The chief of these, in my opinion, is the tendency to continuous growth of the galls, even after all that could be discovered were removed. This hypotheses as to cause would explain in a measure, as would any animal or vegatable parasite, the communicability of the trouble and would conform otherwise to the characters required of an organism responsible for the irritation which excites excessive corky growth, that is, growth of just these dangerous galls.

The European writers already cited regard this "root-craw" as non-parasitic; Soraurer suggesting that bending of the roots in transplanting

[25] Report Ohio State Hort. Soc. **29**, 75 (1895) Also Bull. Ohio Expt. Station, **79**, 112 (1897).

may cause these abnormal deposits. The reasons, which from present study, render this hypothesis untenable, have already been stated at some length. A writer in a recent German publication[26] refers to the suggested connection between *Heterodera radicicola* and Wurzelkropfe in Russia. He finds other nematodes upon the surface of the galls but does not support the suggested connection of this species. The final solution of the problem offers an inviting, though difficult field.

DAMAGES RESULTING FROM CROWN GALL.

With a new trouble of this sort, it is not easy to make exact statement concerning losses or damages. Enough is already known to warn fruit growers against this malady as a very dangerous one. From observations made in Ohio there seems no reason to believe that peach trees affected with crown gall at transplanting age will ever come to successful fruiting. This has been true in a number of cases under observation; in other cases, trees becoming affected, possibly after transplanting, have likewise failed to give full crops of fruit. By far the largest number of such trees may be expected to die before they have attained bearing size and age. Those which actually survive will commonly be unprofitable. I am aware that other claims are made as to the behavior of similarly affected fruit trees in southern orchards. The statements herein made are based upon Ohio observations. It would therefore appear that the amount of damage from crown gall will be in somewhat direct ratio to the proportion of affected trees at transplanting, and this in turn, will depend upon the state of things in the nursery where the trees are grown. This trouble is so obvious that it should be possible to distinguish the affected trees very readily. This applies of course to trees having evident galls; it is quite probable that some other adjacent trees may be affected at this age and later show the usual symptoms. It is altogether safe to reject every tree having the galls upon any part of it. In time we may learn more about the trees growing in proximity to them. Since 1890, a greater or less number of affected peach trees have been delivered to Ohio purchasers. Only a very few of these appear to have been grown in the state, the larger portion coming from the east, south and north in the order named. The writer has made personal inspection of bundles of trees that contained quite a portion of diseased ones. One lot of 400 Smock had 24 diseased trees, that is 6 per cent. Other varieties from the same lot had about the same amount of crown gall. One orchard in Lawrence county, containing 200 trees purchased in New Jersey, was grubbed out at seven years of age, without having borne a single profitable crop, although other trees of like age situated near them had yielded fruit. These trees were badly affected when delivered and were nearly all of them diseased at the time of removal. The owner informs me that scarcely any were free from the

[26] 2 Abt. Centralblatt für Bacteriologie u Parasitenk, IV, 89.

galls, while some of the excresences upon the roots were extremely large. This man was certainly damaged by this diseased stock. Another parallel case occurred in Ottawa county. Two or three neighbors purchased 1,500 peach trees in the fall of 1895; these were set in favorable land the following spring and were examined by the writer in June, 1897. At the date of examination about 50 per cent. of the trees in one lot were apparently affected with the crown gall. It was stated by the growers that some trees were observed to be affected at the time of purchase, and some that had died the first season were replaced by the nurseryman. There is little doubt that the whole of the disease in this instance is due to the affected stock, since older orchards upon the same farms and adjacent to these trees were entirely free from the crown gall except where the affected stock had been used for replanting. The damages in this case are certainly large, admitting, for the most part, of estimation under established principles. There is one feature, namely, that of soil infection by the diseased trees, that cannot so well be estimated. In replanting such an orchard as the one referred to, it would seem safer to abandon the rows in question and to plant in rows alternating with the present ones. The evidence cited on previous pages indicates danger of infection of the replants in case they are set where the diseased trees were taken out.

WHAT CAN BE DONE TO PREVENT CROWN GALL?

Thus far we have been unable by experiments with lime, sulfur and wood ashes to cure any trees affected by crown gall. The nature of the disease, as previously explained, is such as to give small hopes of cure although favorable results from the use of Bordeaux mixture applied to the gall by boring are reported from California. Practical measures must be chiefly preventive, and chief of these will be the rejection of affected nursery stock. Any trees showing rough, gall-growths, like those in the illustrations, should be thrown out and burned. This applies to the purchaser and to the nurseryman as well. These trees will inflict damage if used for planting and have no legitimate trade value. While, as a matter of investigation, we shall continue to experiment with these affected trees, planting them in a place set apart for that purpose, it is doubtful whether the orchardist can afford to set desirable fruit lands with affected stock, even for experiment. Should he desire, however, to take the risk involved, we can scarcely say that he will endanger his neighbor by so doing. The fruit grower owes it to himself, that he permit no affected trees to be sold him; the nurseryman, likewise, must for the protection of his business destroy such of these affected trees as he may happen to grow, or purchase from other nurserymen for delivery to his customers.

IV. FUNGOUS DISEASES OF THE PEACH.

1. PEACH ROT.

While the fungous diseases of the peach do not rank with those of the plum in destructiveness, several of them are quite damaging, and we must, it seems, give first rank to the fruit rot or brown rot. The belief that peaches rot solely because of the weather is often expressed; but while, to be sure, the weather influences the amount of rot, it is only a condition and not the cause of peach rot. This is truly a fungous disease, due to the rot fungus, *Monilia fructigena* Pers. The weather simply influences the amount of rot by offering favorable or unfavorable condi-

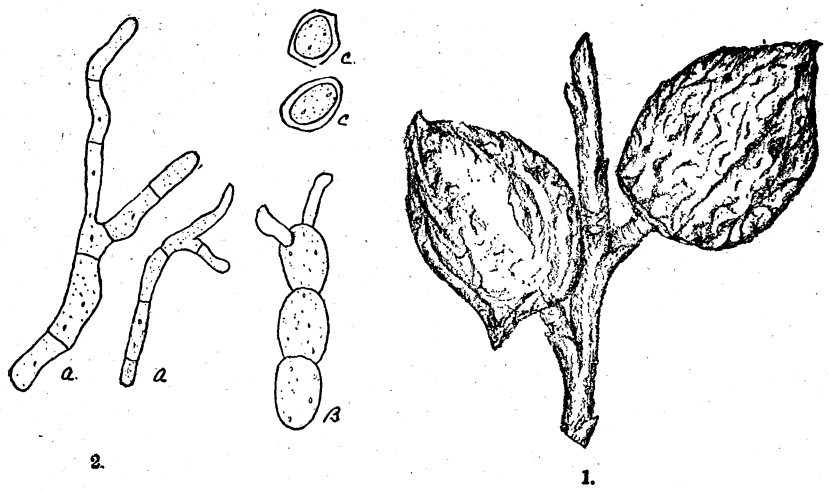


Fig. 8. *Monilia fructigena* in mummy peaches. At 1, midwinter mummies are shown, natural size. At 2, the forms of the *hyyhæ* developed by keeping these mummies in a moist chamber twenty-four hours. 2, *a*, *a*, *b* threads and resting cells or *gemmæ* (?)*c* from the preceding, both magnified about 760 diameters. (From drawing by Mrs. Selby.)

tions of heat and moisture. This rot fungus, as indeed have most fungi, has its growth favored by warm or hot weather and abundant moisture. If this warmth and moisture come together near ripening time we may expect serious loss of fruit. But the chief consideration for the present, is that the rot fungus is always found in the decaying fruits. We may rightly, then, turn attention to the fungus in question. Figure 8 will show something of the characters of this fungus. At 1 are shown two rotted and dried up "mummy" peaches, which were gathered in mid-winter. Upon wetting and placing these in a moist chamber for twenty-fours, it was found that the fungus still lived in the mummies. Some of the forms of threads are shown at 2 a, b, c. At the same time a great

abundance of ash-colored spores was produced upon the outside of the rotten peaches. Similar results may be had if one places a freshly rotted peach under a tumbler or dish where it will be kept moist. These ash-colored, powdery masses of spores are easily scattered by the wind and rain and will cause mischief where they find a suitable place. Favorable places are numerous; such will be found in a dense cluster of fruit or where the fruit is densely shaded by leaves in contact; and in case of warm, April showers at the time of blossoming, these spores from the mummy peaches may enter through the blossoms and cause sad havoc in the form of twig blight.[27] It may be a matter of surprise to some, to hear that this rot fungus destroys the twigs and blossoms of the peach. But close observers in the orchard at harvest time have often called my attention to the death of the twigs and branches bearing rotten fruit. Yet, even these observers have usually missed the early spring blighting of twigs and destruction of blossoms. Unquestionably this fungus is responsible for the injuries just named. Therefore, in dealing with it we must know where and when to strike.

It is first to be observed that the loss of fruit from the monilia is much more a matter of weather conditions than is even usually supposed. We are accustomed to find much rot among early varieties like Hale, Alexander and Crawford's Early, and are consequently likely to call these susceptible varieties. The large grower sometimes finds that Smock and Salway show the greatest losses. A large amount of rot in any variety may be expected during hot, wet weather at ripening time, and there seems no sufficient reason to regard early sorts, on the whole, as more liable to rot than late sorts. As before stated, the favorable conditions determine the amount of rot, though it may also be true that these conditions more commonly occur about the ripening time of the early varieties. Late varieties succumb when met by hot, rainy weather at ripening. To induce rot, the spores of the fungus must gain entrance into the peach, and a decided difference in the texture of the peach skin would have some effect. This difference, however, may be given too much weight. The pin punctures of the curculio with early peaches as with plums are a fertile source of rot infection.

THE PREVENTION OF PEACH ROT.

As shown above the rot fungus survives the winter in the mummy peaches; and the same holds true for mummy plums and cherries, since the same fungus is found in all the stone fruits. To what extent it may survive in twigs cannot be stated. The resting forms of the fungus are shown above, Fig. 8, 2, b, c. All that is needed to induce their growth is a period of warm, rainy weather, such as commonly comes in April and May of each year. So long, therefore, as the mummy fruits are per-

[27] Journal of Mycology, V, 123–134: VII, 36–39, w. Pl. V, VI.

mitted to remain on the trees we must expect an abundance of rot fungus and the losses it causes. All rotted peaches should be removed from the trees as soon as they appear and before the advent of the spring rains. This is the first step in preventing rot. If these are permitted to remain on the trees over winter, they should be burned when gathered; the better plan is to remove the rotten fruits as they appear in the fall or in early winter, when they may be dropped on the ground.

Without this destruction of the mummy fruits other methods will not be likely to succeed, though the disease may not succumb to this alone. Chester[28] has conducted experiments in spraying peach trees for the prevention of rot. Results of the second season show a three-to-four-fold increase of sound fruit on sprayed trees of Hale and Early Rivers. In this work Bordeaux mixture is recommended to be used just before the blossoms open, Bordeaux mixture and Paris green when the fruit has

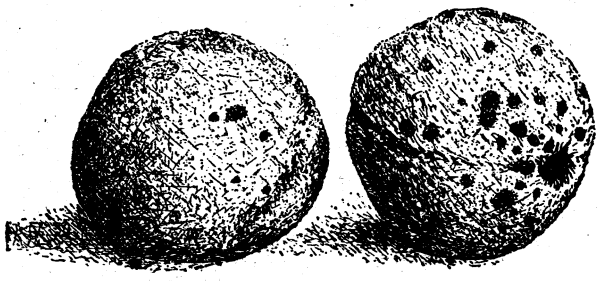


FIG. 9. Peaches showing spots caused by scab fungus. Two-thirds natural size.
(After Arthur, Bulletin 19. Experiment Station of Purdue University.)

set, copper acetate solution (8 oz. to the barrel) when the fruit begins to color and a repetition of this treatment in case of weather favorable to the rot. This differs from the treatment in the spray calendar of this Station (Bulletin 79) only in the use of copper acetate instead of ammoniacal solution of copper carbonate.

The prompt removal of rotted fruit is urged under all circumstances; spraying may or may not prove profitable. The careful thinning of the fruit may sometimes be very helpful in preventing rot.

2. PEACH SCAB.

In peach scab we have a disease sometimes mistaken for a peculiarity of certain varieties of peaches. Growers have often remarked in my hearing that seedling peaches and some sorts like the Salway and Morris' White were frequently dark spotted, one sided, or even cracked open, and that "this seems peculiar to the varieties." The dark spotting and cracking of the fruit, as shown in Fig. 9, is really a disease caused

[28] Bulletin Delaware Expt. Sta., XXXIV (1897.)

by a parasitic plant, the scab fungus, *Cladosporium carpophilum* Thüm. It is most prevalent under the conditions favorable to the growth of this fungus; the scab is much worse during rainy seasons than in dry ones, moisture seeming to be the chief requirement. Certain varieties of peaches appear more susceptible to scab than others, just as certain varieties of apple suffer more than others from the apple scab. The matter to be kept in mind is, that without the fungus we do not have scab on the fruit. The fungus has its beginning in a spore or spores deposited upon the fruit (See Fig. 10, A and B). From the spore the threads of the fungus are afterwards developed (C, Fig. 10), and these must get their subsistence from the exterior of the peach. Accordingly there is hardening of the fruit beneath the scabby areas, and in severe

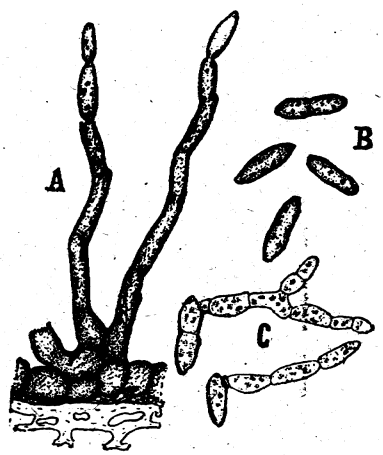


FIG. 10. The scab fungus, *Cladosporium carpophilum* Thüm, much enlarged, A, two filaments bearing immature spores; B, mature spores, C, spores germinating. All magnified 525 diameters.
(After Arthur, Bulletin 19)

cases of scab the affected side cracks open. In these latter not more than half of the peach properly matures, and in all cases the scab disfigures the fruit, making it necessary to accept an inferior price for it. In the trees experimented upon in 1896, as shown on page 252, 70 per cent. of the peaches were scabby, and half of this number cracked open. It is difficult to state scab losses in exact terms, but it seems well within the fact to estimate the loss at from 20 to 50 per cent. of the crop in the case referred to. This is but a form fungus (that is, a fungus of which we know but the simple state figured), and it has been found upon branches where it passes the winter. It is plain to the casual observer that scab occurs continuously upon the same trees. From this we may know where to expect it. The experiments detailed elsewhere show that persistent spraying of the peach trees with weak Bordeaux mixture reduced the amount of scab. It seems possible after a time to destroy most of

the fungus upon trees receiving treatment. Fine peaches are worth growing, while scabby ones are scarcely worth the picking. With such peaches as those upon which the experiments were made the spray treatment may be made profitable.

It seems, from specimens first brought to the writer's notice by Dr. B. D. Halsted, that the scab fungus also attacks the leaves of the peach, causing in them a shot-hole effect, similar to the one produced in plums by *Cylindrosporium* The latter fungus has not been found upon peach trees in Ohio, though it is reported by Prof. Alwood to be troublesome in Virginia. The shot-hole effects mentioned above are illustrated in Fig. 11, page 230.

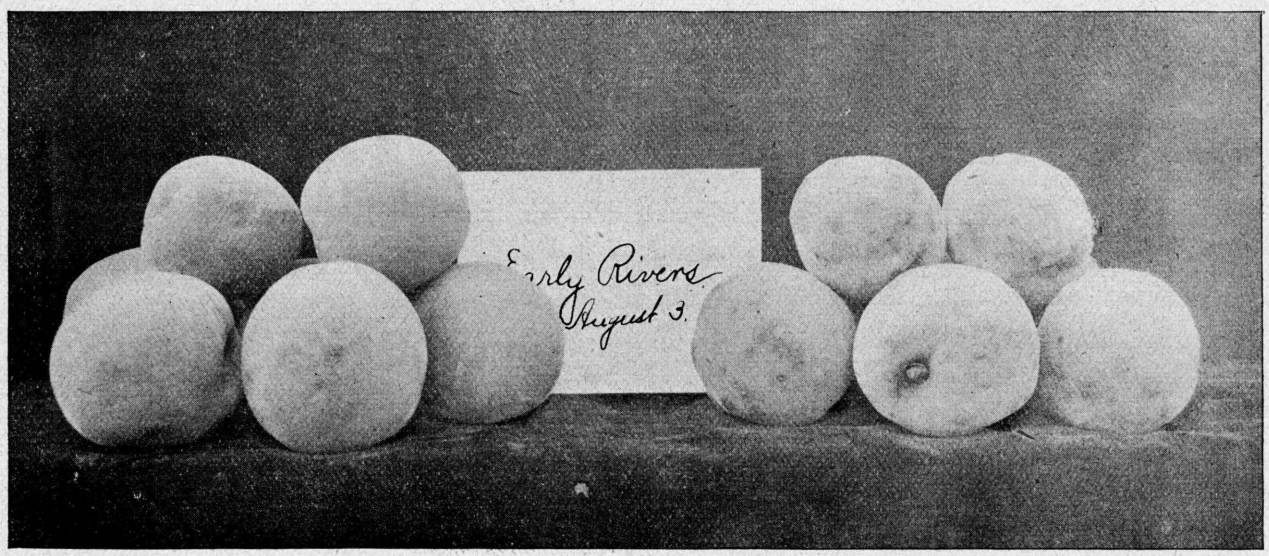
3. BROWN OR PUSTULAR SPOT.

Some idea of the appearance of peaches affected with what has been called by the above name, may be gathered from the illustration, plate VII. This pustular spot is comparatively a new disease in Ohio, and possibly for the United States. So far as known it was not observed in this state previous to 1895. While it may have been present locally much longer, this time marks its appearance on a large scale. The writer's attention was first attracted to the disease in 1894 upon early peaches at Petoskey, Mich. These peaches, offered in the market, were badly disfigured, having numerous, pimply, red spots, with light brown centers, after the manner of those shown in the cut. Careful examination was made in Ohio during that year, but none of the trouble discovered. The same disease did appear, however, throughout Ottawa county and possibly elsewhere the following year. Taft[29] has described this trouble as first coming to notice in Michigan in 1893. He has referred it to *Helminthosporium carpophilum* Lév. That this is a fungous disease is well proven by the constant presence of fungus hypæ in the spots and by the marked results obtained by spraying with fungicides. The disease is first apparent as small, rusty brown spots upon the upper or exposed side of the peaches as early as June 1st. After the fruit droops the spots are usually turned towards the observer. These spots increase in size and develop light brown centers about one to two millimeters in diameter, but are not otherwise conspicuous until the fruit begins to ripen.

From ripening time forward there is much difference in the effects upon different varieties. Upon Early Rivers, Alexander and possibly other early, white sorts, the pustular development is quite marked. Upon yellow varieties the pustular appearance is commonly lacking, there being but the light brown center with a red border of greater or less width. Prof. Taft informs me that the pustular spot seems to be worse in Michigan upon the Wager variety and peaches of that type.

[29] Bulletin Michigan Experiment Station, 103, 57 (1894).

PLATE VII.



Brown or pustular spot of peach. The pustular effect on this variety, Early Rivers, is much more marked than upon many other sorts. (From a photograph, 1895.)

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During the two seasons over which it has been studied in Ohio this spot has been found on most varieties and in several counties. Sturtevant and Hill's Chili were badly affected during the years 1895 and 1896. The spot was likewise found upon Early Rivers, Early Crawford, Alexander, Late Crawford, Smock, Wheeler, Steven's Rareripe, Mountain Rose, Oldmixon, Elberta and Salway. It does not appear that any variety is free from its attacks. Spores of the fungus of pustular spot are not always found, but where present they are 2-7 septate and otherwise conform to the characters of the form-genus Helminthosporium, to which the fungus seems referable. Von Thümen[30] lists two species of Helminthosporium; *H. carpophilum* Lév. and *H. rhabdiferum* B. & B. It is not unlikely that our species is one of these. A similar trouble is found upon apricots in this country.

The fungus of this spot is superficial in its development and therefore easily reached by spraying. In both 1895 and 1896 this trouble was reduced by two or three applications of Bordeaux mixture, made after the fruit had set, from 16 per cent. on unsprayed trees to 1 per cent. upon the trees receiving three of the later applications. In all spraying of peach trees in foliage the half strength Bordeaux mixture (2 lbs. copper sulfate, 2 lbs. lime to 50 gallons of water) is the one to be employed. There is no other fungous disease that seems to yield more readily than this to spraying with fungicides.

4. ANTHRACNOSE OF PEACH.

As noted in one paper[31] upon this disease called pustular spot, the Helminthosporium was not always apparent in the spots. Instead some question was raised as to the possible presence of another fungus, that of peach anthracnose, *Glœosporium lœticolor* Berk., which has been reported from Europe upon the fruit of the peach.[32] It is believed from the study made that the effect of the anthracnose is somewhat similar to that mentioned in preceding paragraphs. It is quite possible that we have both diseases now and have confused them. Upon this point further specimens and study are required.

5. PEACH MILDEW.

There is another disease of the peach which also at times attacks the fruit, but is found more commonly on the leaves and twigs; this is mildew, *Sphærotheca pannosa* Lév.(?) This disease will be our turning point from those affecting the fruit of the peach to those found upon leaves and twigs. As its name indicates, the fungus forms a whitish

[30] Die Pilze der Obstgewächse, 75, (1887).
[31] Twenty-ninth Report, Ohio State Hort., Soc. p. 81, (1895.)
[32] Von Thümen, loc. cit.

covering upon the affected parts. It is most common upon the leaves and twigs, where it is a serious drawback to the growth of the tree. Nurserymen find that certain varieties suffer more than others from mildew, Crawford's Early being often badly affected. Smith[33] has recorded his observation that this fungus attacks chiefly or exclusively those varieties of peaches without gland bearing leaves. He records that "trees with gland bearing leaves were free from mildew and mildewed trees bore leaves destitute of glands." Whether or not there are any exceptions to this general statement it seems clear that some varieties suffer severely from the mildew while others are almost or quite free from it.

Upon the fruit, this mildew causes large, light colored spots, with an enormous multiplication of epidermal hairs or fuzz of the peach. Under the affected spots there is a hardening of the fruit and the consequent effect upon the quality is less marked though quite similar to that produced by the scab. To cut off and burn affected shoots is recommended as a preventive measure for mildew. Spraying is unlikely to yield favorable results.

6. LEAF CURL OF THE PEACH.

It is well known that the leaves do an important work for the plant. Any disease, therefore, which attacks the leaves, seriously interrupting or impairing their functional activity, will prove detrimental to the health of the plant. In the leaf curl we have such a disease of our peach trees. With us it stands alone in its class, when only the fungous diseases of the peach are considered, but we find its kindred in the plum bladders or plum pockets and in a swelling and curling of the leaves on scarlet oak. Like the others of which we have been treating, this leaf curl is caused by a minute plant parasite, the leaf curl fungus, *Exoascus deformans* (B.) Fuckel., which attacks both leaves and new shoots. The leaves attacked by the fungus are thickened, and much distorted; the twigs are similarly thickened and enlarged, but do not show the curling tendencies observed in the leaves. There is great variety in the distortions upon peach leaves caused by the curl fungus; small areas are often much arched and yellowish or reddish in color. When much of the leaf is involved the curling and arching toward one surface produces at times so strong a convexity as to bring the edges of the leaf nearly together. The illustration (Plate VIII), kindly furnished by Prof. G. F. Atkinson, will make clear the effects caused by the exoascus. The affected and distorted areas have usually a paler color, varying from yellowish to red.

The arching and swelling of the parts affected by the fungus is caused by the multiplication of the cells of the leaf, and this in turn is due to the presence of the fungus near the surface toward which the arch-

[33] Journal Mycology, VII, 90-91.

PLATE VIII.

Leaf curl of peach caused by *Exoascus deformans* (B) Fuckel. Fig. 1 from Ithaca, N. Y., with leaves, petioles and a portion of the stem affected; Fig. 2 from Auburn, Ala.

(After Atkinson, Bulletin 73, Experiment Station of Cornell University.)

ing occurs. The hyphæ of the fungus grow among the cells, and have a characteristic form easily recognized under the microscope. The cells of this growth are more or less quadrangular and are often wedge shaped.

HOW DOES THE FUNGUS GET UPON THE LEAVES?

In answering this we will explain likewise how it comes upon the new shoots. The masses of hyphæ pass the periods of late summer, fall and winter, in the tissues of the leaf buds; that is, the mycelium which they form is perennial in the buds. With the beginning of spring growth in the tree there is growth of the fungus as well, the new leaves and shoots being affected as they are put forth. The amount of infection determines the extent of the subsequent distortion. From these facts, well established by careful study, come various practical inferences or conclusions. It is plain that if there is none of the fungus upon the tree there will be no resting mycelium in the buds. We may infer properly, I think, that the amount of surviving mycelium is somewhat dependent upon the extent of the disease during the previous season. But here we are met with a demand to explain the enormous development of leaf curl in certain seasons.

Why was the curl so prevalent in 1892, and in 1893 and again in 1897? I believe we may seek the explanation in the difference in temperature and rainfall at the time of the infection of the new growth; that is, in the weather conditions of April and early May. This fungus, like that of apple scab, appears to flourish best during cool, rainy weather. When we compare the weather conditions of the different seasons, as has been done in table VII, the coincidence of destructive leaf curl with frequent showers during April and May, and especially with low April and May temperatures is well brought out. Mr. William Miller, of Gypsum, estimates his loss from leaf curl on certain varieties in 1893, at 40 per cent. of the crop, while the loss in 1894 was not over 5 per cent. By the careful counts of Mr. Britton in 1896, from 3 year old Elberta peach trees in Mr. Miller's orchard, we find 2.2 per cent. of the leaves affected with curl, while in the same orchard in 1897, equally careful counts by Mr. B. H. Thorne, showed from 80 to 95 per cent. of curled leaves on the same variety. By reference to the weather records at Sandusky, 10 miles east and somewhat south of Gypsum, for these respective seasons, we find that in 1893 there were 18 days of April on which .01 inch or more rain fell, a total rainfall of 4.95 inches and a mean temperature of 46.80° F. In 1895 there were 10 days of April on which .01 of an inch or more rain fell, and a total precipitation of 2.25 inches, with a temperature 48.8° F. 1896 and 1897 show similar contrasts in the April weather; in 1896, .01 inch or more rain fell upon 11 days, a trace on 4 other days, a total rainfall of 4.12 inches for April and a mean temperature of 53.8° F.; while in 1897 this amount of rain fell upon 12 different days during April with

a trace upon 6 more, making 18 rainy days in all with a total of 2.11 inches rainfall and a mean temperature of 47.2° F., for the month. Here we note that there must be a coincident rainy days and low temperature (in this respect contrast 1896 and 1897.) Other points will be noted from a study of the table. It will also be observed that the temperatures for May during 1893 and 1897 are likewise below the normal. It seems that we may safely trust early April weather to foreshadow serious prevalence of peach leaf curl. The weather conditions as herein given for the region about Sandusky Bay may not have been duplicated elsewhere for the same periods, but the relation of the disease to the weather conditions will doubtless be found to hold good generally. In the study of leaf curl it was seen that during seasons of moderate spring rainfall and fairly high temperatures, chiefly the outer and older leaves were attacked by the curl, whereas, during such seasons as 1893 and 1897 the infection extended to practically all the leaves formed during the months of April, May and early June. We may here perceive the direct connection between the meteorological conditions and the extent of the leaf curl. Should these conditions favor rapid development of the exoascus we may expect extended infection of the new leaves by this fungus. Herein lies another point of great interest in the study of the effects of the fungicidal treatment upon the leaf curl of the peach. It is evident that the fungicide cannot reach the leaves before emergence from the bud, and except in cases of treatment year after year, we are not justified in expecting that the first leaves upon treated and untreated trees will show any marked difference in the proportions affected by the fungus. Experiment shows practically no difference in this regard. We may rightfully expect treatment during a given season to reduce the amount of the surviving fungus mycelium in the leaf buds. This effect will be manifest only after the lapse of a year. We may call it the cumulative effect of spraying for leaf curl. The more immediate results to be expected from spraying for leaf curl are of much the same nature; they cannot from the circumstances be expected upon the earliest leaves. The spraying may, and as shown by the experiments given in detail elsewhere, does prevent the infection of the succeeding leaves and shoots. In this connection the reader is referred to the results of the leaf curl experiments for 1897. It will be seen first of all that three or more thorough sprayings with Bordeaux mixture in 1896 so reduced the amount of curl that the disease was practically no drawback to the growth of the trees in 1897. This is especially marked in rows 14, 15 and 16 of the south Elberta orchard, page 254. Row 15, which had been treated in 1895 and 1896, was left without further treatment in 1897 and showed 14.3 per cent. of curled leaves on June 14; row 14, in addition to receiving the same treatment as row 15 in 1895 and 1896, was sprayed in 1897, it showed 8.3 per cent. of the curled leaves on June 12; row 9 which received no treatment during 1895 and 1896, but was treated twice in 1897 showed 41 per cent.

of curled leaves on June 15. While strongly contrasting with this and the preceding is row 16, the trees of which are the same variety and age of the others just mentioned, but differing in that they received no treatment whatever during these years of 1895, 1896 and 1897. They show this absence of treatment in about 90 per cent., (88 per cent. as actually

FIG. 11.—Spot and shot-hole effects on peach leaves, natural size. (From drawing by Mrs. Selby.)

determined) of curled leaves on June 12. Without entering into a more detailed statement here of the results of the spraying experiments it seems that we are justified in concluding:

First, that two applications of Bordeaux mixture in a season favorable to leaf curl will sufficiently prevent the disease to enable the tree to carry a crop of fruit without very great loss through dropping.

Second, that in seasons like 1897, the unsprayed trees of varieties susceptible to leaf curl can scarcely carry the crop of fruit when suffering from such injury to the leaves.

Third, that thorough spraying the preceding season is even more effective in the prevention of leaf curl than during the season of its occurrence.

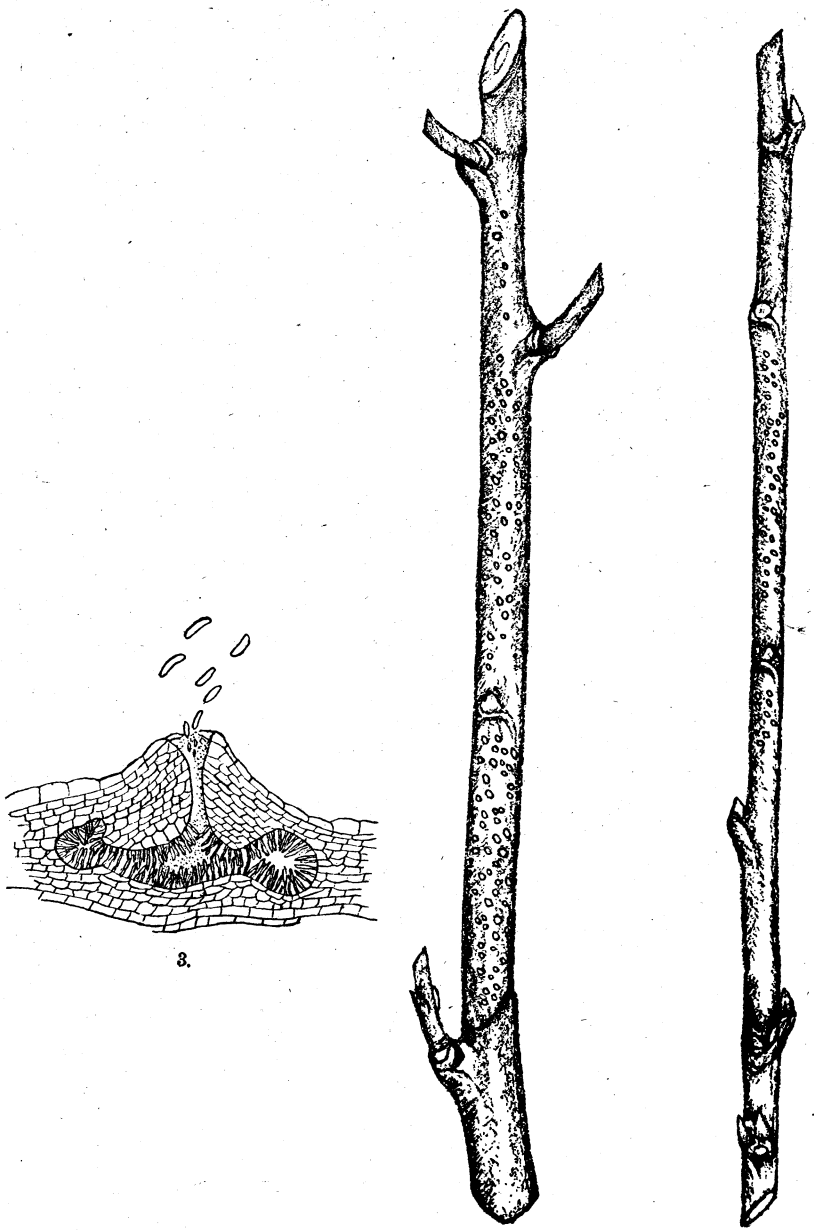
There is a wide difference in the susceptibility of the different varieties to the attacks of the leaf curl. Some susceptible varieties are Mountain Rose, Oldmixon, Globe, Elberta, Scott's Nonpareil, Red Cheek and some others. Upon such varieties and in a season where there is a crop of fruit to save, the April weather will prove a reliable guide for the orchardist. Following such Aprils as those of 1893 and 1897 the curl is certain to do more or less injury. It is then that two sprayings with Bordeaux mixture will be likely to prove profitable; the first of full strength mixture, to be made just before the blossoms open, the second of half strength mixture (Bordeaux II Calendar) to be made just after the calyx drops from the fruit.

6. LEAF SPOTS OF THE PEACH.

In addition to the somewhat variegated color of the leaves on trees growing in improperly drained soil (see page 185) there are other discolorations of peach leaves. These we will discuss under the heading given. The commoner leaf spot is that found upon unhealthy or languishing trees; here the leaves have often red colored or dead spots like those shown in Fig. 11. Associated with the dead spots is the shot-hole appearance where these dead areas have fallen out. Such leaf spots may have various and possibly diverse causes. In general, so far as the peach is concerned, such spots appear to stand for a somewhat languishing condition of the tree, but it is not clear that this condition is the result of the spotting of the leaves, such as happens with or from Cylindrosporum (shot-hole fungus) upon plums and cherry. At the south such spotting is produced by the same cylindrosporium that attacks the plum, and in Alabama, Georgia and Florida also by the peach rust fungus, *Puccinia pruni-spinosae*. The Ohio leaf spots of the peach often have two or more species of fungi associated with them. Dr. Halsted of New Jersey, has kindly sent me specimens of peach leaves resembling those in Fig. 11, in which the fungus of peach scab, *Cladosporium carpophilum* Thüm., is associated with the spots; like specimens have been collected here. In connection with similar spots I have found species of Helminthosporium. The cladosporium is thought to be the common associate with the shot-hole effect on the peach in Ohio.

Upon smaller, languishing trees dead spots, five to ten millimeters in diameter, are often found. These are usually without highly colored border, such as occurs with the shot-hole appearance, the transition to normal tissue being quite abrupt. In such spots a species of Macros-

PLATE IX.



3. 2.

Constriction disease of peach stems: Fig. 1, section of affected stem of nursery tree, showing general effect and situation of pycnidia; Fig. 2, same on slender twig, both natural size. Fig. 3, section through a pycnidium of the fungus, *Phoma persicæ* Sacc., and showing spores, magnified about 500 diameters. (From drawing by Mrs. Selby.)

porium (?) referred to *Macrosporium commune* Rabh., has frequently been found. From the probable saprophyitic nature of this fungus it is not likely to be the cause of the spots, which may arise, possibly from malnutrition induced in another manner.

The leaves of peach trees growing in very shaded locations are sometimes attacked by yet another fungus inducing pale, yellowish spots in the leaves. The under surface of such spots is found to be covered with a frosty growth of fungus hyphæ; from this appearance, which is apparently more common in the south than with us, the disease has been called the frosty mildew. The fungus associated with this appearance is *Cercosporella persica* Sacc., one closely allied to the leaf spot fungi of other cultivated plants. The writer has collected this fungus upon a stray peach tree within a thicket border in Fairfield county but not elsewhere. It does not seem probable that this leaf spot or frosty mildew will prove seriously injurious, even though it become much more prevalent under such conditions as excessive leaf growth induced by the use of nitrogenious manures or by other causes.

7. CONSTRICTION DISEASE OF STEM AND BRANCH.

A disease of the stem of heeled nursery stock and of the branches of older trees has been studied. This quite closely resembles in its course and symptoms the "constriction or lacing disease" (*Einschnurungskrankheit*) of the fir, described by European authors,[34] and like that on the conifers is due to a species of fungus of the genus Phoma, in this case *Phoma persicæ* Sacc. Attention was first called to the trouble by specimens received by the Entomologist from Mr. D. S. Barber, of Castalia, in March, 1896. These specimens showed limited constriction of the stems at the points of disease, with the portions dead or dying above. Fungus hyphæ were present in the diseased stems, but it was not possible to determine what the fungus might be. Further material was requested and with it came the following letter from Mr. Barber:

"Yours of the 25th received. Under separate cover I mail you a bundle of tips of young diseased peach trees as you requested. These trees under consideration are a lot of 800 which I bought from a nurseryman last fall and heeled in over winter, and I now expect, the coming month, to take them up and finish out an orchard which was partially set one year ago. Perhaps I had better explain more definitely what I mean by heeling in. When we purchase trees in the fall, we dig a trench say ten feet long, throwing the dirt up on side, spread trees along with roots in trench, laying them at an angle of about 45 degrees, then throw dirt over roots and body up as far as lower limbs; the soil so removed to cover makes another trench, which is filled with trees as at first, and continue in this manner until all are laid in or heeled, as it is termed. The object of this method is to protect the young trees from the rigors of winter. This lot of 800 occupy a space of ground 10x27 feet, laid in this manner. You will see from this explanation the trees are very recently from the nursery and have never fruited. I will say that a neighbor has

[34] Tubeuf, Pflanzenkrankheiten durch kryp. Par. ver., 482, (1895).

an old pear orchard located about ten rods from this heeling-in ground. I have examined these pear trees but failed to find any branches that had similar spots to the ones I send you. There are very few of the peach trees affected, apparently. After you have given the tips a thorough investigation please give me your opinion as to whether or not I run a risk in planting them.

Very truly yours,

(Signed) D. S. BARBER.

Further examination and a subsequent visit to Castalia disclosed the full nature of the disease. Destruction and close cutting of the affected stock was recommended. Diseased branches with the same apparent cause were later examined from Sandusky county, from eastern Erie county and from elsewhere, but in no other instance was the injury so large as that at Castalia. Mr. Barber gives some estimate of his loss in a letter of later date as follows:

"Yours of the 26th ult. received, some days since. I remember all about the diseased trees that you speak of, very distinctly. When I came to setting out they were so badly effected I set but few of them, but those that were set did fairly well considering that the stem had to be cut so low in order to remove all of the diseased part. I can find no branches that look to me to be affected as those were, unless it should be the enclosed specimens, which I cut from trees two years from setting, and which are located probably twenty rods from where the affected ones were planted. With best wishes for you and yours, I remain,

"Very truly yours,

(signed) "D. S. BARBER."

"Castalia, O., April 8, 1897."

A drawing has been made of the affected parts and to show the character of the fungus. The last specimens referred to were diseased like the earlier specimens. No light has been thrown upon the source of infection in Mr. Barber's trees nor for other instances. The fungus is not uncommon, apparently, but its injuries have not yet proved frequent.

Cutting off the diseased branches, followed by prompt burning of them, is recognized as a palliative. The fungus survives, doubtless, in the diseased parts, and may be checked by burning these portions as soon as observed.

8. TWIG BLIGHT AND TWIG SPOTS.

Reference has already been made to the serious destruction of blossoms and twigs of the peach, caused by the brown rot, *Monilia fructigena*. That serious destruction may come from this fungus is well attested by the observations of Smith, and by others made in Ohio. The prevention of this form of twig blight consists in the removal of the mummy peaches. Like destruction of twigs may result from the same fungus at harvest time. No other serious twig blight has come under observation, although a dark spotting of new shoots has been frequently seen. Examination of the spots shows a thick, felted covering of fungus mycelium, which is dark brown or black in color. In certain cases it has seemed that this fungus may be the same as that affecting the fruit of the apple, namely, a species of Leptothyrium.[35]

[35] Bulletin 79, p. 133.

9. ROOT ROT.

In a part of one peach orchard at Gypsum, Ottawa county, where there is a dense clay sub-soil and probably also insufficient drainage, a great many trees have died out. Upon removal, the roots, especially the deeper ones, show extended decay. On these decayed parts there is usually an abundance of the mycelium of some fungus, the whole having at times a characteristic odor. A similar condition has been reported from Texas by Smith.[36] As in the case he mentions, the mycelium apparently belongs to some hymenomycetous fungus. It is not altogether clear that this is a specific disease, and it may be referable to the imperfect drainage about the trees in question. The trouble is mentioned in the hope of obtaining more information concerning it.

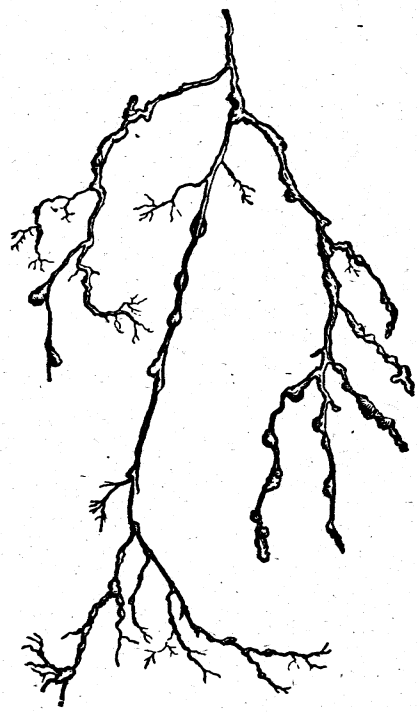


FIG. 12. Roots of peach from the south with small nematode galls.
(After Smith, Farmers' Bulletin No. 17, U. S. Department of Agriculture.)

V. DISEASES DUE TO ANIMAL ORGANISMS.

1. NEMATODES—BORERS—ROOT LICE.

The chief animal parasites of the peach come within the field of the Entomologist and do not call for treatment here. Some of them, how-

[36] Journal Mycology, VII, 377.

ever, produce symptoms so similar to those of other diseases that mistakes often occur. In the warmer regions certain eelworms attack the roots of the peach, producing on them small enlargements, such as shown in Fig. 12. In this trouble we have one similar to the effects of nematodes upon greenhouse roses and other forced plants, for discussion of which the reader is referred to an earlier bulletin.[37] While the nematodes have been met with upon gooseberry plants, none have been observed upon peach trees in this state.

The peach borer, Sannina, is a common enemy of the orchardist. Its presence is shown by the exuded gum about the base of the tree and by the burrows of the larvæ beneath the bark. Another insect, the peach aphis, *Aphis persicae-niger* Smith, is often a serious pest in sandy or loamy soils, more especially the former. Its effects are most apparent upon trees that have been transplanted from one to three years, often causing symptoms readily mistaken for those of yellows. I have seen many examples of trees transplanted one or two years attacked by this insect. Smith[38] speaks of them and suggests that they are carried by the yellow ant, which is a constant attendant on this aphis wherever found upon the tree. Trees thus affected are very much dwarfed and stunted, being scarcely larger at two years than at transplanting. The shoots are slender upon such trees and the leaves similarly dwarfed. With this the possible resemblance to yellows ends, there being none of the other characteristics of that disease. Root examination will disclose the lice when they are present. This peach louse is small and dark, strongly resembling that upon plum and cherry. It is altogether likely that carbon bisulpfid can be successfully employed to destroy this aphis.

[37] Bulletin 73, O. A. E. S.

[38] Bulletin 9, Sect Vegetable Path., U. S. Department Agriculture.

II. EXPERIMENTS IN SPRAYING PEACH TREES.

BY AUGUSTINE D. SELBY.

Begining in 1895, experiments in spraying peach trees were conducted for three seasons by the Station Botanist. These were upon a commercial scale and in co-operation with Mr. William Miller, of Gypsum, Ottawa county, Ohio, in his orchards at that place. Throughout this work the same plan has been followed and in all of it Mr. Miller has rendered invaluable assistance. It is desired also to express my obligations to Mr. Fred Walters, Mr. Miller's foreman, and to Messrs. Jno. C. Britton and Bertram H. Thorne, who assisted in conducting the spraying experiments in 1896 and 1897 respectively. The laborious countings of peaches indicated in Tables II and III, were made by Mr. Britton and those upon leaf curl, Table IV, by Mr. Thorne. The cordial and efficient aid rendered by all these gentlemen above named made these experiments possible as conducted.

The prevalence of leaf curl, rot and scab first led to these trials. The trees of the Elberta variety had shown themselves decidedly susceptible to the attacks of leaf curl in 1893, while an older orchard, largely of Salways, gave good opportunity to test the effects of spraying for scab and for some other obscure troubles. There was a crop of fruit in 1895 and again in 1896, but none at all in 1897. The pustular spot made its appearance upon the Elberta peaches in the south orchard in 1895 and again in 1896. During both these seasons there was an abundance of scab on the Salway variety. It will thus be seen that these experiments cover (1) leaf curl, (2) pustular spot of the peach and (3) peach scab. The results will be discussed in the order named.

GENERAL PLAN OF THE EXPERIMENTS.

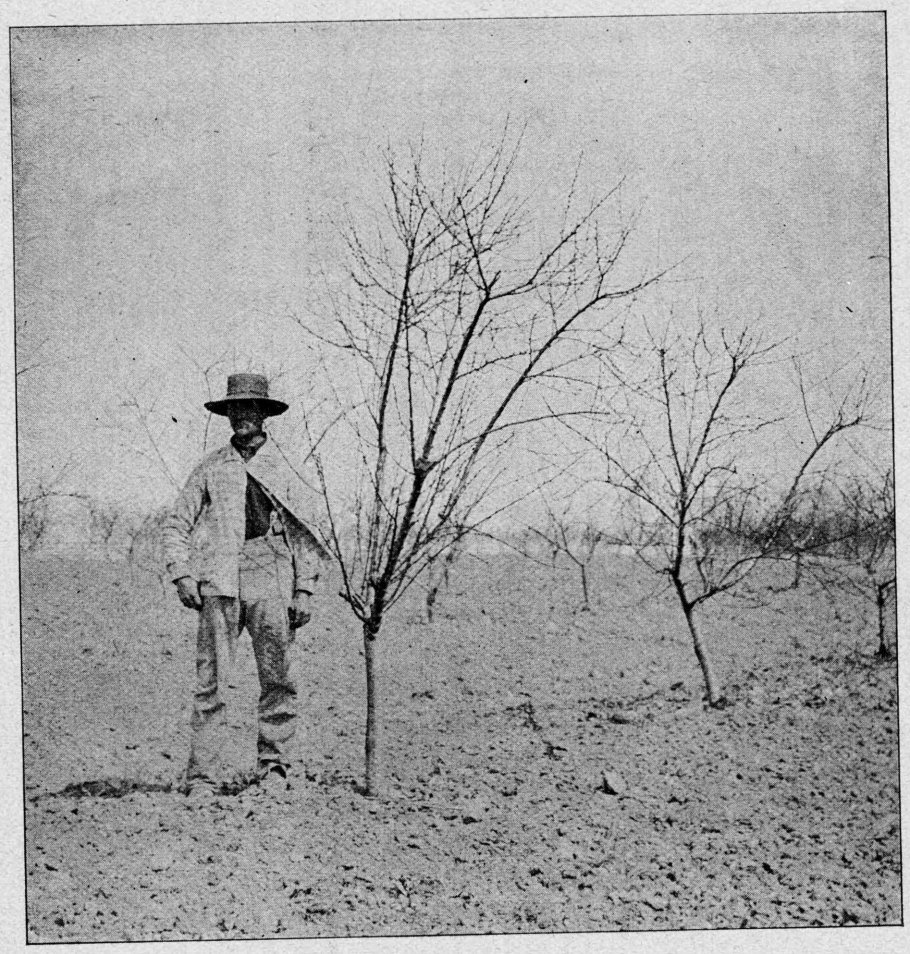
As before stated, these experiments were to test the spraying of peaches upon a commercial scale. It was not deemed expedient to deal with a number of fungicides. Bordeaux mixture was selected, because of its well known efficacy and comparatively easy preparation. For two seasons copper sulfate solution alone was tested for the first application. Previous experiments in spraying peaches had demonstrated fully the tender character of peach foliage at all times. The first care, therefore, was to select a strength of mixture which might be employed with safety. Earlier trials of the 75 gallon formula of Bordeaux mixture (1 to 12½) at this Station having shown its efficacy, this strength or the equivalent of copper sulfate solution was used for the first spraying only. For all applications made after the unfolding of the leaves one-half this strength of Bordeaux mixture or the 150 gallon formula was employed.

For the sake of brevity, the 75 gallon formula is called Bordeaux I, and the 150 gallon formula, Bordeaux II, in the spray calendar and in the discussions of this paper. In all cases the mixture was prepared by using equal weights of copper sulfate and unslaked lime; that is, an excess of lime was uniformly added. Since it was first necessary to determine the effect of a standard fungicide the original plan was followed through the three years, except that the copper sulfate solution was not used in 1897. The results obtained seem to have justified fully the use of the dilute mixtures above described. The experiments were conducted on trees in two orchards, known respectively as the South orchard and the North orchard. The South orchard occupies about 18 acres; the rows extend from north to south, and contain 38 trees each on the west side and a greater number towards the east. In this experiment the rows are numbered from the west, as shown in diagram A. The trees of this orchard were chiefly set in 1889 and 1890, respectively, and are fairly uniform throughout the orchard. The land was newly cleared, the soil a somewhat stiff, light colored clay of good fertility. No crops had been grown upon it previous to setting the orchard. The trees were set rather high, as the land is flat, and no tiles were laid.

The North orchard consists partly of older and partly of younger trees; these were set at different times and not in uniform rows. The northern part, with which the experiment has to do, is of the Salway variety, 14 years old, planted in rows extending from south of east to north of west. These rows are numbered from the south. The newer or southern part of this orchard is made up of trees of the Elberta variety, set in 1892, the rows running from east to west and joining obliquely to the foregoing. The soil in the older part is similar to that of the South orchard, being a light colored clay. The soil in the newer part of the orchard is a darker and more fertile clay, shading off at the east into a semi-muck soil. The older trees formerly extended into this latter soil, but were removed when it was discovered to be unsuited to them. Diagram B will give some idea of the situation of this orchard. In the Elberta variety the rows are numbered north and south from the large open ditch shown in the diagram.

The following schemes will show the treatment given the different rows of these orchards for the several years, 1″, 2″, 3″, 4″, are used to show that these rows received the applications known as first, second, third and fourth respectively. The first application was made each year just before the opening of the blossoms, the actual dates varying from April 18th to April 26th, differing according to the forwardness of the season. The second application was made just after the calyx had dropped from the fruit, the dates ranging from May 5th to May 11th. The third application was usually made about ten days to two weeks after the second, and the fourth two weeks later still. These later dates are varied somewhat in 1897, as shown in the details given.

PLATE X.



At the time of the first spraying, April 26, 1895. This shows condition of buds when spraying is begun, and also the one-sided development of the tree when attached by root-rot. (From a photograph.)

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DIAGRAM "A."

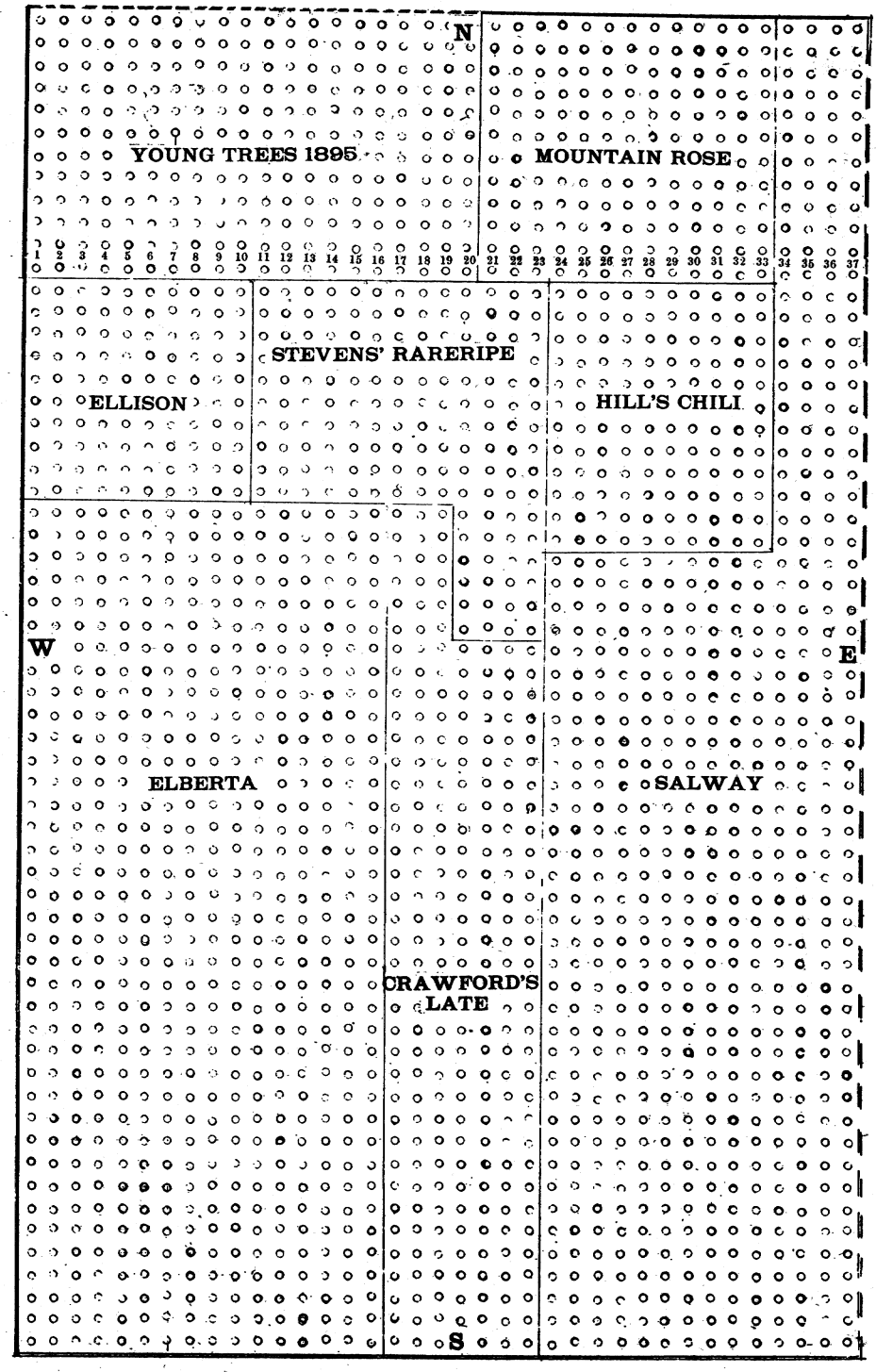
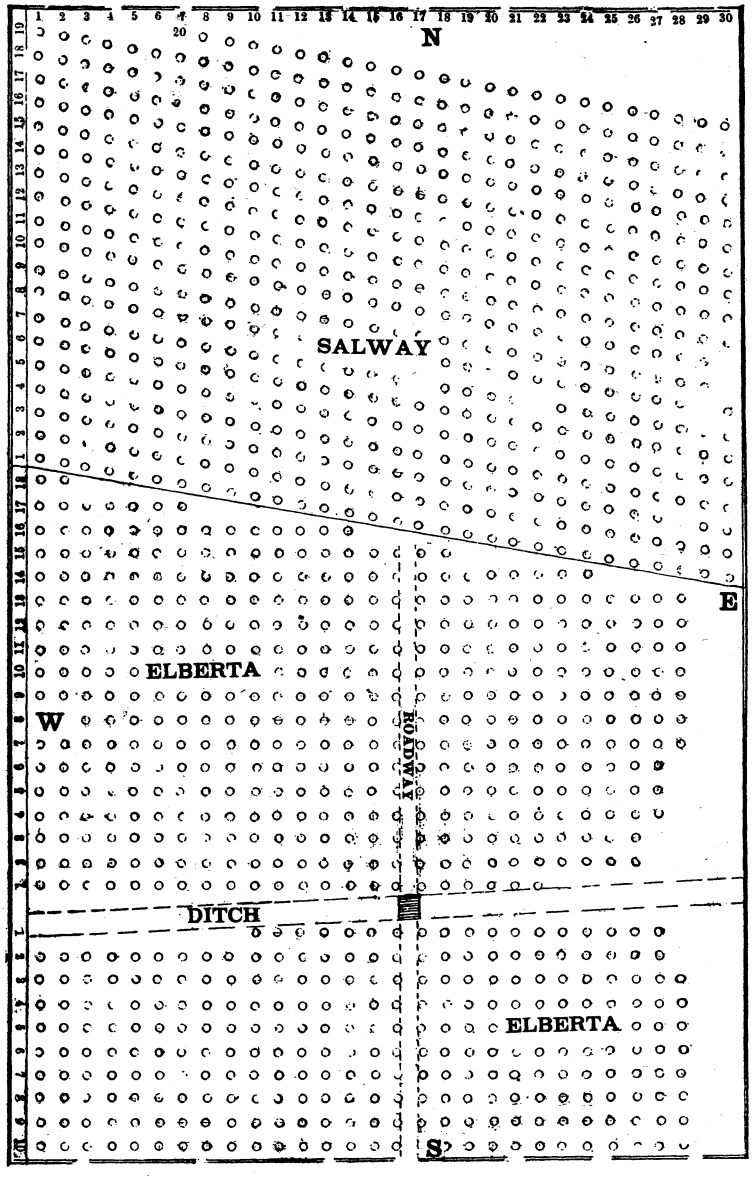


Diagram "A" showing plan of South Orchard, of Wm. Miller, Gypsum, O. The broken lines indicate a greater extension at those points than is shown here.

DIAGRAM "B."



North Orchard of Salway and Elberta varieties belonging to
WM. MILLER, GYPSUM, O.
The broken lines at north and south, show further extension of the orchard.

SOUTH ORCHARD SPRAYING SCHEME.

Variety.	No. of row.	Treatment: In 1895.	In 1896.	In 1897.
Elberta.....	1	1″ lye solution.....	3″ and 4″ Bord. II..	Unsprayed.
"	2	"	"	"
"	3	"	"	"
"	4	"	"	3″ & 4″ Bord. II.
"	5	"	Unsprayed	2″ & 4″ Bord. II.
"	6	"	2″ Bord. II.....	2″ Bord. II.
"	7	"	2″, 3″ & 4″ Bord.II..	Unsprayed.
"	8	2″ & 3″ Bord. II.....	" ...	1″ & 2″ Bord. I,
"	9	Unsprayed	Unsprayed	" [& II
"	10	1″,2″&3″Bord.I,& II	1″, 2″, 3″ & 4″ Bord. I, & II.	Unsprayed.
"	11	1″,2″&3″Bord.I,& II	"	1″ Bord. I .....
"	12	1″,2″&3″Bord.I,& II	1″, 2″, 3″ & 4″ Cop. Sul. & Bord. II.....	1″ and 2″ Bord.I,
"	13	1″, 2″ &3″ Cop. Sul. and Bord. I, & II...	1″, 2″, 3″ and 4″ C. Sul. and Bord. II..	[& II
"	14	1″,2″&3″Bord.I,& II	1″, 2″, 3″ & 4″ Bord.	1″,2″,3″,4″ Bord.
"	15	1″,2″ & 3″ C. Sul. & Bord. I, & II	I, & II. "	[I, & II 1″, 3″, & 4″ Bord.
"	16	Unsprayed.....	Unsprayed	Unsprayed.[I, & II
Crawford.....	17	1″, only, Bord. I.....	"	"
"	18	1″ & 2″ Bord. I.....	"	"
Salway.....	33	....	"	"
"	34	....	2″, 3″and 4″Bord.II	"
"	35	.....	" ...	2″ and 4″ Bord, II
"	36	.....	Unsprayed	"
"	37	.....	"	Unsprayed.
		Dates.	Dates.	Dates.
		1″, April 25—26.....	1″, April 18—20.....	1″, April 23.
		2″, May 16.	2″, May 7	2″, May 5—6.
		3″, May 21—22.....	3″, May 22—23.....	3″, May 11.
		.....	4″, June 3—5	4″, May 28.

NORTH ORCHARD SPRAYING SCHEME.

Variety.	No. of row.	Treatment. In 1895.	In 1896.	In 1897.
Elberta, S. of Ditch	1	None	None	Unsprayed.
"	2	"	"	1″, Bord. I. [I&II.
"	3	"	"	1″,2″,3″,4″, Bord.
"	4	"	"	2″,3″,4,″ Bord. II.
"	5	"	"	Unsprayed.
"	6	"	"	"
N. of Ditch.	1	1″, Cop. Sul. Sol.	Unsprayed	"
"	2	"	"	"
"	3	"	"	"
"	4	"	3″ and 4″, Bord. II.	"
"	5	"	3″ and 4″, Bord. II.	"
"	6	"	Unsprayed	2″ & 4″, Bord. II.
"	7	"	2″, 3″, & 4″, Bord. II	2″ & 4″, Bord. II.
	8	1,″ 2″, and 3″, Cop. Sul. and Bord. II.	2″, 3″ & 4″, Bord. II	Unsprayed.
"	9	1″, 2″, and 3″, Cop. Sul. and Bord. II.	2″, 3″ & 4″, Bord. II	1″, Bord. II.
"	10	Unsprayed	Unsprayed	1″&2″,Bord.I&II.
"	11	1″,2″&3″, Bord.I&II		
"	12	2″ and 3″, Bord II.		
"	13	2″, Bord. II.		
	14	Unsprayed	1″ and 2″, Bord. II.	Unsprayed.
	15	"	Unsprayed	"
Salway	1	"	"	"
"	2	"	"	" [& II.
"	3	"	"	1″, 2″, 4″, Bord. I
"	4	1″, 2″, 3″, 4″, Bord. I, & II.	1″, 2″, 3″, 4″, Bord. I, & II	1″, 2″, 4″, Bord. I
"	5	1″, 3″ and 4″, Bord. I, & II.	1″, 2″, 3″, 4″, Bord. I, & II	[& II. Unsprayed.
"	6	Unsprayed	2″, 3″,& 4″, Bord. II	"
"	7	"	2″, 3″, & 4″, Bord. II	"
"	8	"	Unsprayed	"
"	9	"	2″, 3″ & 4″, Bord. II	"
"	10	"	2″ 3″ & 4″, Bord. II	"
"	11	"		
		Dates.	Dates.	Dates.
		1″, April 25–26	1″, April 18–20	1″, April 23.
		2″, May 16	2″, May 7	2″, May 5–6.
		3″, May 21–22	3″, May 22–23	3″, May 11.
		4″,	4″, June 3–5	4″, May 28.

It will be seen that in these experiments we have to deal with more than one disease. This will answer most of the questions suggested in looking over the scheme of spraying for the several years. Those who study tables I and II. will discover that the first spraying produced little or no effect upon the pustular spot of the fruit (contrast rows 8, 11, 12, and 14, South orchard), while the later sprayings serve this purpose. In the study of leaf curl results opposite conditions prevail, the first and second sprayings availing most for this trouble. Such possible results were in mind when the plan of the work was outlined. In giving the actual

outcome of the spraying it seems best to state the results of each of the years separately. This we will proceed to do:

I. RESULTS OF SPRAYING PEACHES IN 1895.

During this season there was very slight development of leaf curl upon the trees. No counts were made and no difference observed between sprayed and unsprayed trees, the amount of curl in any case being so small as to be without evident effect. It was thought by superficial examination that some favorable results upon the amount of scab were secured from spraying the trees of the Salway variety this year, but upon this subject the experiments of 1896 are much more conclusive. The pustular spot appeared upon the peaches of the South orchard that year. The following counts were accordingly made by Mr. Walters and are sufficiently self-explanatory.

TABLE I—SHOWING PREVENTION OF PUSTULAR SPOT ON PEACHES, 1895.

SOUTH ELBERTA ORCHARD.

Row.	Tree.	Treatment.	Total No. peaches.	No. spotted peaches.	Per cent. spotted.
9	24	Unsprayed	215	68	31.6
9	25	Unsprayed	178	65	36.5
16	6	Unsprayed	188	43	28.2
16	19	Unsprayed	98	15	15.7
		Totals and average	679	191	28.13
15	6	Sprayed once April 24, (copper sulfate, 4 pounds)	242	48	19.83
10	24	1st, 2d and 3d sprayings	261	14	5.36
10	25	1st, 2d and 3d sprayings	312	11	3.52
14	5	1st, 2d and 3d sprayings	101	11	10.89
15	20	1st, 2d and 3d sprayings	278	36	12.95
		Totals and average	952	72	7.56

The sprayed trees here included were all treated three times.
First, April 24–25, copper sulfate, 4 pounds and Bord. 4 pounds or Bord. I.
Second, May 10–11, Bord., II, except rows 12, 13 and 14, Bord., I.
Third, May 21–22, Bord. II.

Comparison is invited between these results and the more complete data for 1896.

II. RESULTS OF SPRAYING EXPERIMENTS IN 1896.

In 1896 effort was made to determine the effect of spraying with all possible exactness. The season was one of rather more than average rainfall at the point where the spraying was done. This was a year of

fair fruit crop for these particular orchards, thus enabling us to make a most satisfactory test of spraying for the fungus-parasites of the fruit of the peach. The season, while rather more favorable for leaf curl than 1895, did not call forth a serious prevalence of this trouble. The results may be better stated separately under three divisions.

1. EFFECTS OF SPRAYING UPON THE AMOUNT OF LEAF CURL.

As already stated, there was only a moderate development of this disease, though the effects of the two years' spraying were plainly noticeable. Effort was not made to state these in the form of percentage and the results therefore lack somewhat in the exactness of statement. They have been already given to some extent in another place.[39] By counting the leaves upon part of the tree and multiplying this result by an estimated factor it was determined that an Elberta peaeh tree, four years of age, in the North orchard, bore 24,000 leaves. Six trees upon this basis had 144,000 leaves, upon which, in row 10, were found 3,177 leaves affected with the curl, that is, 2.21 per cent. of the leaves were thus attacked. The following counts made June 1 to June 12, will give an idea of the comparative results. These are stated separately for the Elberta variety in both North and South orchards. In each the trees upon which counts were made were in adjacent rows and under otherwise as nearly the same conditions as possible:

ON ELBERTA TREES, SEVEN AND EIGHT YEARS OLD,—SOUTH ORCHARD.

Total number of leaves affected with curl on trees counted:

Row 4, 3d and 4th sprayings, 6 trees, 545 leaves curled.
Row 5, unsprayed, 6 trees, 755 leaves curled.
Row 6, 3d spraying only, 6 trees, 132 curled.
Row 7, 2d, 3d and 4th sprayings, 6 trees, 82 curled.
Row 9, unsprayed, 6 trees, 2,028 curled.
Row 10, 1st, 2d, 3d and 4th sprayings, 6 trees, 45 curled.
Row 15, 1st, 2d, 3d and 4th sprayings, 5 trees, 18 curled.
Row 16, unsprayed, 5 trees, 590 curled.

ON SAME VARIETY, FOUR YEARS OLD,—NORTH ORCHARD:

Row 7, 2d, 3d and 4th sprayings, 3 trees, 168 curled.
Row 8, 2d, 3d and 4th sprayings, 3 trees, 138 curled.
Row 10, unsprayed, 9 trees, 3,339 curled.
Row 11, 1st 2d, 3d and 4th sprayings, 4 trees, 374 curled.
Row 14, 1st and 2d sprayings, 4 trees, 31 curled.
Row 15, unsprayed, 4 trees, 1,738 curled.

Upon the Stevens', Rareripe and Ellison varieties, where no counts were made, the comparative effects of spraying were similar to those upon the Elberta, though the actual amount of diseased leaves was very much less. Taking the above figures, we find that four sprayings pre-

[39] Report Ohio State Hort. Soc., 30, 88.

vented about 94 per cent. of the leaf curl. But here another difficulty confronts us, namely to decide how much of this effect is due to the work of 1896 and how much of it to the cumulative effect of both years' sprayings. This determination is clearer in the results of next year, see page 255.

2. EFFECT UPON THE PUSTULAR SPOT.

In determining the effects of spraying on this disease we had to deal with about 500 peach trees of 7 and 8 years of age of the Elberta variety. It seemed impossible to determine the results without counting the affected and non-affected peaches at time of picking. To this end it was decided to count the peaches from certain rows, namely 2, 5, 6, 8, 9, 10, 11, 12, 14 and 16 of the South orchard; see tables. The pickers gathered at each time from each tree separately, leaving the fruit in a separate basket by the tree. Mr. Britton then went over this fruit for each tree separately and noted the condition of the fruit upon a blank designed for this purpose. The amount of labor and care involved in this method can be realized by those who are familiar with handling fruit. The fruit was gathered into baskets and separately counted as to bushels from each row. Here, however it was more difficult to keep the record thoroughly accurate, owing to the variation in size of packages used, yet it is believed that the amounts are fairly accurate as they appear in the table. Tables II and III show the results obtained in this way upon the trees in the South orchard, the only one in which this disease largely prevailed.

TABLE II—SHOWING RESULTS OF SPRAYING ELBERTA PEACHES FOR PUSTULAR SPOT IN 1896—SOUTH ORCHARD.

Date of picking.	Number of row.	Treatments received.	Number peaches—total.	Yield, bushels—total.	Number peaches in bushel.	Number spotted peaches—total.	Number badly spotted.	Number with 5 spots or less.	Number medium spotted.	Per cent spotted.	Number of picking.
Aug. 24	2	3″ and 4″.	537	5.	.....	57	2	49	6	10.62	First.
Aug. 25	2	"	617	4.75	.....	49	0	44	5	7.94	Second.
Aug. 27	2	"	1,417	4.6	.....	38	2	33	3	2.68	Third.
Aug. 28	2	"	1.187	11	.....	54	2	45	7	4.54	Fourth.
Aug. 31	2	"	2,767	18	.....	73	5	56	12	2.63	Fifth.
		Total.....	6,525	43.3	153	271	11	227	33	4.15	
Aug. 24	5	Untreated	834	5.5	.....	236	25	174	37	28.29	First.
Aug. 25	5	"	1,201	7.75	.....	207	32	118	57	17.23	Second.
Aug. 27	5	"	1,610	10	.....	295	70	146	79	18.32	Third.
Aug. 29	5	"	516	3.5	.....	50	8	33	9	9.69	Fourth.
Aug. 31	5	"	2,777	17	.....	342	77	169	106	12.68	Fifth.
		Total.....	6,938	43.75	159	1,130	212	640	288	16.28	
Aug. 24	6	*2″									
Aug. 27	6	"	1,399	8	.....	158	31	91	36	11.3	Third.
Aug. 29	6	"	906	5.5	.....	42	6	28	8	4.64	Fourth.
Aug. 31	6	"	2,269	13.75	.....	100	10	67	23	4.44	Fifth.
		Total	4,574	27.25	168	300	47	186	67	6.58	
Aug. 24	8	2″,3″&4″.	339	2.75	.....	13	0	13	0	3.83	First.
Aug. 25	8	"	1,521	10.0	.....	14	0	14	0	0.92	Second.
Aug. 27	8	"	1,123	6.5	.....	13	0	13	0	1.16	Third.
Aug. 29	8	"	562	3.5	.....	4	0	4	0	0.54	Fourth.
Aug. 31	8	"	2,512	14.5	.....	18	1	14	3	0.71	Fifth.
		Total.....	6,057	37.25	160	62	1	58	3	1.02	
Aug. 24	9	Untreated	798	5.5	.....	196	11	149	36	24.56	First.
Aug. 25	9	"	555	4.75	.....	129	15	87	27	23.27	Second.
Aug. 27	9	"	2,171	12.0	.....	399	100	177	122	18.85	Third.
Aug. 29	9	"	562	3.5	.....	86	16	51	19	15.3	Fourth.
Aug. 31	9	"	3,453	21.5	.....	376	81	176	119	11.19	Fifth.
		Total.....	7,539	47.25	159	1,186	223	640	323	15.73	
	10	†									
Aug. 27	10	2″ and 4″.	649	4	.....	30	3	21	6	4.62	Third.
Aug. 29	10	"	129	1	.....	1	0	1	0	0.07	Fourth.
Aug. 31	10	"	649	4	.....	5	0	5	0	0.07	Fifth.
		Total.....	1,427	9	159	36	3	27	6	1.52	
Aug. 24	11	1″,2″,3″4″	452	3.25	.....	13	0	12	1	2.87	First.
Aug. 26	11	"	1,180	7.0	.....	13	0	13	0	1.10	Second.
Aug. 27	11	"	1,479	8.5	.....	12	0	12	0	0.81	Third.
Aug. 29	11	"	557	3.5	.....	5	0	5	0	0.90	Fourth
Aug. 31	11	"	1,860	10.	.....	18	0	16	2	0.97	Fifth.
		Total.....	5,528	32.25	171	61	0	58	3	1.10	
	12	†									
Aug. 27	12	1″,2″,3″4″	1,145	7	.....	7	0	7	0	0.61	Third.

TABLE II—Concluded.

Date of picking.	Number row.	Treatments received.	Number peaches—total.	Yield bushels—total.	Number peaches in bushel.	Number spotted peaches—total.	Number badly spotted.	Number with 5 spots or less.	Number medium spotted.	Per cent. spotted.	Number of picking.
Aug. 29	12	1″, 2″, 3″ & 4″....	612	3.75	.....	6	1	5	0	0.98	Fourth.
Aug. 31	12	"	1,251	7.5	.....	12	1	9	2	0.95	Fifth.
		Total.....	3,008	18.25	164	25	2	21	2	0.83	
Aug. 24	14	1″, 2″, 3″ & 4″....	574	3.75	.....	11	0	10	1	1.91	First.
Aug. 26	14	except	4,309	25.5	.....	30	1	27	2	0.70	Second.
Aug. 28	14	20 N. trees	2,688	13.5	.....	17	1	14	2	0.63	Third.
Aug. 29	14	.....	897	4.5	.....	9	0	9	0	1.00	Fourth.
Aug. 31	14	.....	2,638	15.	.....	25	0	22	3	0.94	Fifth.
		Total	11,106	62.0	179	92	2	82	8	0.84	
Aug. 24	16	Untreated	833	6.0	.....	180	5	146	29	21.61	First.
Aug. 26	16	"	1,682	8.8	.....	214	27	125	62	12.72	Second.
Aug. 28	16	"	979	6.25	.....	209	50	112	47	21.35	Third.
Aug. 29	16	"	500	3.2	.....	74	23	35	16	14.80	Fourth.
Aug. 31	16	"	1,615	9.75	.....	273	56	145	72	16.90	Fifth.
		Total.....	5,609	34.0	165	950	161	563	226	16.93	

*Not counted first and second pickings.
†First and second pickings not counted.

TABLE III—SHOWING SUMMARY OF SPRAYING RESULTS ON PUSTULAR SPOT IN 1896—SOUTH ORCHARD.

Number row.	Number trees.	Treatments received.	Number peaches.	Number to a tree.	Yield—Bushels.	Number spotted peaches—Total.	Number badly spotted.	Per cent. spotted.	Per cent. badly spotted.	Number peaches in bushel.	Age of trees.
2	37	3″ and 4″..	6,525	179	43.33	271	11	4.15	.17	153	7 & 8 yrs.
8	35	2″,3″ & 4″	6,057	170	37.25	62	1	1.02	.....	160	" "
6	35	2″.....	4,574	131	27.25	300	47	6.58	1.03	168	" "
10	12	2″ and 4″..	1,427	119	9.	36	3	2.52	.02	159	" "
5	38	Untreated..	6,938	182	43.75	1,130	212	16.28	3.05	159	" "
9	33	" ..	7,539	228	47.25	1,186	223	15.73	2.96	159	" "
16	33	" ..	5,609	167	34.	950	161	16.93	2.87	152	" "
11	33	1″,2″,3″,4″	5,528	167	32.25	61	.....	1.10	.....	171	" "
14	31	1″,2″,3″,4″	11,106	273	62.	92	2	.84	.....	179	" "
12	26	1″,2″,3″,4″	3,008	116	18.50	25	2	.83	.....	164	" "

From these tables it will be observed that the peaches from the unsprayed trees of rows 5, 9 and 16 give an average of 16 per cent. of spotted peaches of which 2.9 per cent. were badly spotted. That the peaches on the trees in rows 11, 12 and 14 which received the four sprayings gave an average of less than 1 per cent. of spotted peaches (actually .94) of which but .02 per cent. were badly spotted. On row 8, three sprayings reduced the per cent. of spotted peaches to almost the same as that of the rows just named. Part of row 10, receiving second and fourth sprayings, comes next, with but 2.52 per cent. of spotted peaches, and next to it row 2, receiving third and fourth sprayings, and having 4.15 per cent. of spotted peaches.

3. EFFECT UPON THE SCAB.

There was little or no scab upon the Elberta peaches of the South orchard with which we have just been dealing. In the North orchard, on the other hand, the trees of the Elberta variety, though younger, stand adjacent to the old orchard of Salway upon which the scab has been prevalent for years. The statement of scab prevention accordingly has to do with the Elberta of the North orchard, with the Salway of the North orchard and with the latter variety in the South orchard. In the following tables these results are stated and also the counts made of the rotten peaches on the Elberta sort.

TABLE IV—Showing Results of Spraying on Scab and Rot in North Elberta Orchard, 1896.

Date of picking.		Number row.	Treatment received.	Total number peaches.	Total yield—bushels.	Number scabby.	Per cent. scabby.	Number rotten.	Per cent. rotten.	Pickings.
Sept.	1	8	2″, 3″ & 4″..	666	.....	15	2.26	6	.....	First.
	5	8	2″, 3″ & 4″..	675	.....	26	3.85	6	.....	Second.
	8	8	2″, 3″ & 4″..	724	.....	41	5.63	6	.....	Third.
			Total.....	2,065	12.5	82	3.97	18	.87	
Sept.	1	10	Untreated....	325	.....	22	6.8	10	.....	First.
	5	10	" ...	636	.....	80	12.6	6	.....	Second.
	8	10	" ...	1,639	.....	249	15.01	21	.....	Third.
			Total	2,600	18.0	351	13.5	37	1.42	
Sept.	1	11	1″, 2″, 3″,4″	662	.....	35	5.3	13	.....	First.
	5	11	1″, 2″, 3″,4″	659	.....	27	4.1	8	.....	Second.
	8	11	1″, 2″, 3″,4″	696	.....	25	3.6	8	....	Third.
			Total.....	2,017	13.25	87	4.31	29	1.43	
Sept.	1	13*w*	1″, 3″ & 4″..	320	.....	7	2.2	10	.....	First.
	5	13*w*	1″, 3″ & 4″..	1,664	.....	54	3.3	4	.....	Second.
	8	13*w*	1″, 3″ & 4″..	858	.....	17	2.0	3	.....	Third.
					16.5	.....	2.74	.....	.59	
Sept.	5	13*e*	1″ and 2″.....	208	.....	18	.....	3	.....	Second.
	8	13*e*	1″ and 2″.....	15	.....	6	10.76	.....	1.34	Third.
			Total.....	3,065	.....	102	3.32	20	.65	
Sept.	1	14	1″ and 2″.....	343	.....	88	22.8	8	.....	First.
	7	14	1″ and 2″.....	1,120	.....	282	25.2	20	.....	Second.
	8	14	1″ and 2″.....	275	.....	60	21.8	6	.....	Third.
			Total.....	1,738	12.5	430	24.74	34	1.95	

TABLE V—Showing Summary of Results of Spraying for Scab in 1896.

1. On North Elberta Orchard.

No. row.	No. trees.	Treatment—1895.	Treatment—1896.	No. peaches.	Yield—bushels.	No. scabby.	Per cent. scabby.	No. rotten.	Per cent. rotten.	Age of trees.
8	20	1″, 2″ and 3″	2″, 3″ and 4″	2,065	12.5	82	3.97	18	0.87	Four years.
14	19	Untreated	1″ and 2″	1,738	12.5	430	24.74	34	1 95	"
13W	16	2″	1″, 3″ and 4″	2,842	16.5	78	2.74	17	0.59	"
13E	7	Untreated	1″ and 2″	223		24	10.76	3	0.65	"
10	28	Untreated	Untreated.	2,600	18	351	13.5	23	1.42	"
11	28	1″, 2″ and 3″	1″, 2″, 3″ and 4″	2,017	13.25	87	4.31	29	1.43	"

2. On Salway—North Orchard.

							No. badly scabbed.	Per cent. totally scabbed.	Per cent. badly scabbed.	
3	22	Untreated	Untreated	2,611	9.25	1,855	862	71.04	32.90	Fourteen years.
8	20	Untreated	Untreated	1,847	7	1,250	395	67.67	21.50	"
11	17	Untreated	Untreated	2,196	7.25	1,377	585	62.70	18.90	"
4	19	1″, 2″, 3″ and 4″	1″, 2″, 3″ and 4″	1,594	6.5	626	47	39.27	2.95	"
6	20	Untreated	2″, 3″ and 4″	2,406	8.5	1,726	1,010	71.70	42.00	"
10	21	Untreated	2″, 3″ and 4″	3,682	9.95	2,458	1,348	70.20	66.75	"

3. On Salway—South Orchard.

35	.....	Untreated	2″, 3″ and 4″	5,478	.....	1,230	486	22.45	8.90	Seven years.
36	.....	Untreated	Untreated	3,393	.....	1,230	608	36.25	17.80	"

III. RESULTS OF SPRAYING FOR LEAF CURL IN 1897.

Experiments of this year in these orchards deal with leaf curl, only, at least in so far as immediate effects can determine. The scheme for this year shows that the spraying was continued upon the Salway variety but this was for next year's possible determination upon the scab. All the fruit buds were killed by the severe winter weather, so that the fruit conditions were known when spraying was begun. The April weather assured a developement of the curl, and the periods between sprays were shortened to get, if possible, full light upon the subject. It will be observed by referring to page 243 that second and fourth sprayings of this year correspond in time with the second and third of 1895 and 1896; the first and second applications being determined by the forwardness of the tree do not vary to any considerable extent.

Counts were made at different dates to secure data for fuller discussion. In these counts a part of the tree was selected for counting and all diseased and healthy leaves were noted. The percentage thus secured was used to represent the condition of the particular tree. Three to six trees were counted for each row and the figures thus obtained are used in the tables. As nearly as possible, the errors were eliminated, though no effort has been made to eliminate unaccounted variations. The latter are few, comparatively. To determine whether errors might occur in selecting upper or lower, northern or southern branches of the trees in question, the relative prevalence of curl was separately determined without showing any striking variation, in 1897.

TABLE VI—SHOWING THE EFFECT OF SPRAYING ELBERTA PEACHES FOR LEAF CURL IN 1897.

1. IN SOUTH ORCHARD.

Row.	No. trees counted.	Treatment. In 1896.	Treatment. In 1897.	Date of counting.	Per cent. curled leaves.	Date of counting.	Per cent. curled leaves.	Proportion of leaves fallen, last count.
5	6*	Unsprayed	2″ and 4″	June 12	80.5	June 18	44.0	60 per cent. fallen.
7	6	2″, 3″ and 4″	Unsprayed	" 14	19.5	" 18	19.0	.....
8	6	2,″ 3″ and 4″	1″ and 2″	" 14	5.6	" 19	6.5	.....
9	6	Unsprayed	1″ and 2″	" 15	41.0	" 19	22.0	10 per cent. fallen.
10	6	1″, 2″, 3″ and 4″	Unsprayed	" 15	22.0	" 19	17.0	5 "
13	6	1″, 2″, 3″ and 4″	1″, 2″, 3″ and 4″	" 12	7.0	" 19	5.5	20 "
14	6	1″, 2″, 3″ and 4″	1″ and 4″	" 12	8.2	" 21	3.8	15 "
15	6	1″, 2″, 3″ and 4″	Unsprayed	" 14	14.2	" 21	8.5	8 "
16	6	Unsprayed	Unsprayed	" 12	88.0	" 18	56.0	55 "
			2. IN NORTH ORCHARD.					
		South of ditch—						
5	.....	Unsprayed	Unsprayed	June 9	85.0	June 17	68.0	
4	.....	Unsprayed	2″, 3″ and 4″	" 9	77.0	" 19	47.0	
3	.....	Unsprayed	1″, 2″, 3″ and 4″	" 10	41.0	" 17	21.0	
5	.....	Unsprayed	1″	" 10	38.0	" 17	23.0	
		North of ditch—						
6	.....	Unsprayed	2″ and 4″	" 10	88.0	" 17	54.0	
9	.....	2″, 3″ and 4″	1″ (closely pruned) ‡	" 10	9.0	" 17	4.0	
9	.....	2″, 3″ and 4″	1″ (not pruned)	" 10	16.0	" 17	7.0	
10	.....	Unsprayed	1″ and 2″ (pruned)	" 11	22.0	" 18	14.0	
10	.....	Unsprayed	1″ and 2″ (not pruned)	" 11	32.0	" 18	18.0	
11	.....	2,″ 3″ and 4″	1″, 2″, 3″ and 4″ (pruned)	" 11	8.0	" 18	4.0	
11	.....	2″, 3″ and 4″	1″, 2″, 3″ and 4″ (not pruned)	" 11	17.0	" 18	8.0	
14	.....	2″	Unsprayed (pruned)	" 11	81.0	" 17	50.0	
14	.....	2″	Unsprayed (not pruned)	" 11	79.0	" 17	50.0	

* These trees were usually numbers 6, 7, 8, and 26, 27, 28 of their respective rows. The leaves of same trees were counted on both dates, and the numbers chosen bring the two series upon two distinctly different soils, namely—a black clay soil and a light colored clay. The larger per cent. of curl was usually found upon the darker soil in the south end of the orchard. The results stated in the table are the averages.

† The dropping of leaves in rows 13 and 14, possibly also to a certain extent in row 5, was due to spray injury. In the other cases it seems an index to the time of dropping for the diseased leaves. On June 22, Mr. Thorne records that in rows 5 and 16 there is "scarcely enough foliage left to cast a shadow."

‡ The pruning here was very close, the trees being cut back severely.

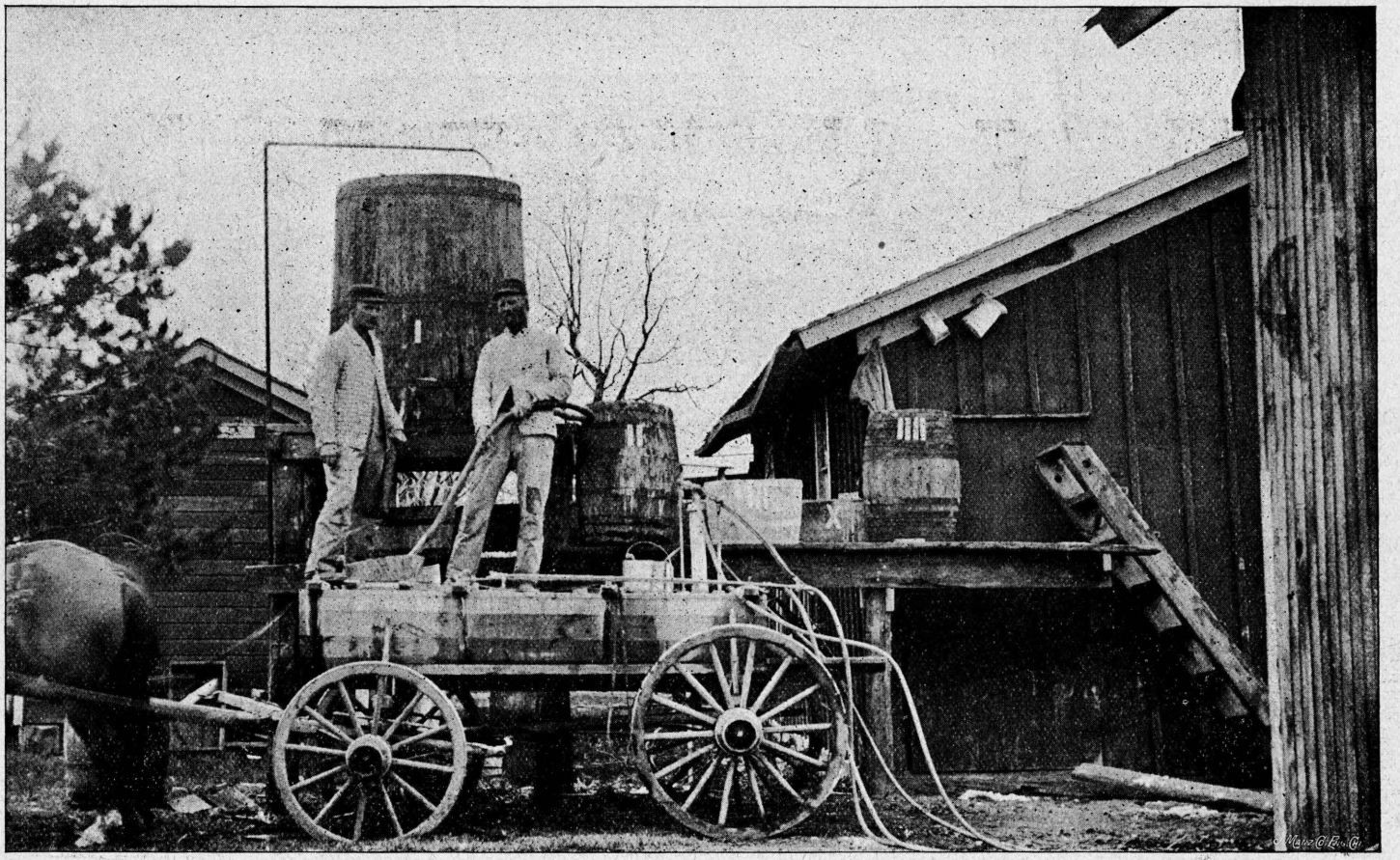
ⱬ Attention is particularly directed to the efficacy of the first spraying, made just before the blossoms opened. The difference in percentage of curl upon the two dates given seems chiefly confined to the trees with most curl and referable to the loss of leaves from dropping and to the beginning of new growth, long delayed by the disease.

IV. SPRAYING OUTFITS AND CONVENIENCES.

Since the spraying of orchards has come to be a matter of such regular practice, greater interest often pertains to appliances and convenience than to anything else connected with spraying. Thanks to the ingenuity of Mr. Miller and to little needs coming to light in practice we were able in the work described in preceding pages to try a fair proportion of these things. In so far as these relate to general conveniences, such as the matter of preparation of stock solution and lime putty, they have already been given in the spray calendar and Bulletin 79. For practical spraying on a commercial scale it is essential to save time in every possible way. Under the old method, possibly now almost obsolete, when the lime was slaked and copper sulfate dissolved for each barrel of mixture, almost as much time was consumed in the preparation as in the application to the trees. Now, on the contrary, we know that by the use of stock solution of copper sulfate, lime putty, water supply conveniently at hand and all things arranged for this work, the time actually consumed in filling a wagon tank holding 175 gallons is from 6 to 12 minutes. Plate XI shows a view of Mr. Miller's device for rapid filling of the spray tank. This consists at one end of a large water tank, I, supplied in this case by wind pump, a barrel, II, for making up the requisite amount of strained milk of lime, a tub, III, in which this solution is prepared from the lime putty, another barrel, IV, containing stock solution of copper sulfate, (40 lbs., to 40 gals.) strainer and cheese—measure, cloth bag are shown just above this barrel—and the lime trough, V, containing the lime putty. The process of filling the tank consists in washing the already strained milk of lime into the tank, adding the solution of copper sulfate and agitating thoroughly with the pump. This is a very convenient and ingenious arrangement. It was found from experience with the ordinary barrel sprayer in 1895, that too much time was lost in driving from the water supply to the orchard. This led to the use of the large wagon tank shown in Plates XI and XII. The pump used, Eureka No. 2, is provided with an agitator and in addition there is one in the tank, reached through the forward trap. Two lines of hose were employed, three men and team being required. Each line rod was provided with three single Vermorel nozzles; latterly one double and one single nozzle provided enough vents for the power of the man at the pump. The field operation of spraying is shown in Plate XII from photograph taken April 25. This wagon tank has a capacity of about 175 gallons. A larger tank may be used in ordinary orchards, if wheels with broad tires are provided. Under these circumstances the capacity of the tank may be safely increased and made to hold from 250 to 300 gallons.

SUMMARY.

1. The peach growing sections of Ohio are situated along the shores of Lake Erie and in the hilly counties in the southeastern portion of the



Wm. Miller's spray rig.—At the filling tank April 23, 1897; Time, 6 to 12 minutes. I. Elevated tank filled by wind-mill pump. II. Barrel into which the lime is strained for each filling. III. Tub in which lime is made up with water, IV. Barrel containing stock solution of copper sulfate, 1 pound to a gallon, measure and strainer above. X. Box in which lime-putty is kept ready for use.

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state. The largest yield from a single county was nearly 500,000 bushels from Ottawa county in 1894.

2. Calls for information and direction in the control of peach diseases led to the present investigation which was continued from 1895 until the present time. Preliminary, general treatment of peach diseases is herein undertaken.

3. Gum exudation on peach trees indicates a wound of some character. Pruning is best done while the trees are dormant, during January, February and March. Peach trees may be killed by being set in undrained soil.

4. Severe winter cold in our lattitude frequently kills-back or otherwise injures peach trees. One form of this injury is the production of dead areas on the sun-exposed sides of the trunks. Freezing causes its maximum injury in soft or unripened tissues.

5. Yellows prevails in practically all the peach growing districts of Ohio, but not to an alarming extent. Rosette has not been found. Basing judgment upon the experience of the past three years it seems possible to control yellows by prompt and thorough measures in the destruction of affected trees by fire, and by care in the purchase of stock for planting.

6. An obscure disease of peach twigs accompanied by copious gum-flow prevails in many parts of the state. The nature and cause of this disease are not definitely known. Close pruning is recommended for its control. Dropsical swellings of the branches have also been noted and like remedies suggested.

7. The crown gall of the peach, especially upon nursery stock, has recently come into marked prominence. This disease has the usual characteristics of a parasitic trouble and takes rank with yellows in its menace to the peach industry. No cure has been found. Destruction of all affected trees is strongly urged whether these be in the hands of the nurseryman or the orchardist.

8. Among the fungous troubles of the peach, the fruit rot takes first rank, with leaf curl, scab and pustular spot in the order named. To prevent the rot, the destruction of the old rotted peaches is the first essential; leaf curl may be greatly reduced and its damages controlled by spraying with Bodreax mixture and the same applies to the scab and to the pustular spot.

9. A constriction disease of nursery stock, due to *Phoma persicæ*, the Monilia twig blight and mildew, as well as some other fungous troubles are to be noted among Ohio orchards. The root rot is possibly of a fungous nature, but is yet under study. Note is made of a few diseases caused by animal organisms because of their confusion with fungous diseases.

10. Experiments in the commercial spraying of peach orchards have been conducted for three years at Gypsum, Ottawa county, in

co-operation with Wm. Miller. These have fully demonstrated the practicability of spraying peach trees with Bordeaux mixture of suitable strength for the control of leaf curl, scab and pustular spot diseases.

11. For leaf curl the effects of spraying are cumulative, apparently by destroying the mycelium of the fungus. Trees of the Elberta variety unsprayed had 88 per cent. of curled leaves in 1897, while those sprayed twice for that season, the first just before the time for blossoming and the second just after dropping of the calyx, showed 41 per cent. of curled leaves, and trees thoroughly treated in 1895 and 1896, though untreated in 1897, had about 30 per cent. of curl. Furthermore, spraying in 1897 following that of the two years previous reduced the amount of curl to less than 8 per cent.

12. In the treatment for leaf curl, the effect for the current season is chiefly referable to the sprayings made just before and just after blossoming time. The cumulative effects are observed where either earlier or later appplications are made.

13. Sprayings for pustular spots are effective after setting of fruit; three treatments reduced the amount of spotted peaches to 1 per cent., two sprayings to 2.5 per cent. where unsprayed trees showed 16 per cent. of spotted peaches. Upon younger orchards slightly less favorable prevention of scab than of pustular spot was secured, while upon old trees results were decidedly favorable, the second season only. The two years' treatment in this case reduced the number of scabby peaches to one-half and the proportion of cracked peaches to one-tenth that upon untreated trees.

14. For early spraying before buds open, Bordeaux I, the 75 gallon formula is recommended, and for later applications, Bordeaux II, the 150 gallon formula, should be used instead. With these mixtures and by use of proper conveniences in spraying, commercial spraying of peach orchards bids fair to become generally practicable. There is no need to fear injury from the mixtures recommended. Occasionally slight falling of the leaves may result when later applications are made at shorter intervals than two weeks.

15. The cost of this spraying is much less on peach trees than on apple trees, because of their smaller size. This cost is less than $1\frac{1}{2}$ cents per tree for each application in foliage; four applications can be made on fairly level orchards for less than 6 cents per tree. This estimate covers the cost of both labor and spray materials.

PLATE XII.

Wm. Miller's spray rig—In the peach orchard April 23, 1897. By this arrangement with large tank and two lines of hose, 3 men are required. One man drives and works pump and two men hold the nozzles. (From a photograph.)

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APPENDIX.

TABLE VII—SHOWING METEOROLOGICAL CONDITIONS AT SANDUSKY, OHIO, FOR APRIL, MAY AND JUNE, DURING THE YEARS 1895–1897.

DAILY TEMPERATURE AND PRECIPITATION AT SANDUSKY, OHIO, APRIL, 1893–1897.

Date.	Mean temperature.				Minimum temperature.				Daily precipitation in hundreths of an inch.			
	1893.	1895.	1896.	1897.	1893.	1895.	1896.	1897.	1893.	1895.	1896.	1897.
1	54	34	49	39	46	32	36	36	2	18	1	.....
2	36	35	26	44	30	31	21	37	.....	7	4	.....
3	57	36	28	40	40	29	22	38	53	.....	T	.....
4	58	42	33	49	52	33	26	38	8	.....	.....	20
5	47	52	36	53	38	39	29	47	.....	.....	.....	T
6	36	57	38	43	34	42	34	41	.....	.....	.....	5
7	59	50	30	39	36	40	27	37	20	85	.....	5
8	64	51	35	40	52	44	30	38	19	33	.....	T
9	44	44	41	35	38	39	35	33	.....	.....	33	52
10	42	40	40	35	40	36	38	29	T	.....	T	T
11	46	35	58	35	36	28	40	32	3	.....	26	26
12	60	48	62	39	50	37	40	32	61	22	.....	T
13	62	48	70	51	54	42	63	40	11	25	.....	51
14	36	42	65	43	35	36	58	41	36	.....	18	.....
15	38	45	68	44	29	38	56	36	34	.....	.....	.....
16	42	42	75	46	31	39	64	38	.....	.....	.....	3
17	47	41	78	38	40	36	69	34	.....	.....	.....	2
18	44	47	76	49	42	40	65	34	.....	.....	.....	.....
19	42	54	66	46	40	43	59	35	23	.....	T	.....
20	51	59	61	30	40	36	50	25	46	.....	207	.....
21	40	62	61	45	33	50	54	30	13	.....	1	.....
22	38	52	46	65	35	42	43	55	.....	14	.....	.....
23	39	51	47	67	34	46	40	56	.....	4	T	7
24	44	62	58	69	38	44	47	57	.....	.....	56	9
25	43	70	57	62	38	58	53	54	21	.....	.....	23
26	48	51	60	53	41	47	50	47	39	T	.....	T
27	53	46	62	44	43	42	54	38	10	10	59	.....
28	50	48	64	57	44	44	60	41	.....	7	.....	.....
29	42	61	53	54	40	49	49	51	11	.....	6	T
30	44	58	63	48	40	52	55	46	85	.....	1	8
Av.	46.8	48.8	53.8	47.0	39.6	40.8	45.6	39.9	.16	.08	.14	.....
								Totals	4.95	2.25	4.12	.....
Number rainy days									19	11	15	18

DAILY TEMPERATURE AND PRECIPITATION AT SANDUSKY, OHIO, MAY, 1893–1897.

Date.	Mean temperature.				Minimum temperature.				Daily precipitation.			
	1893.	1895.	1896.	1897.	1893.	1895.	1896.	1897.	1893.	1895.	1896.	1897.
1	56	51	65	42	45	47	58	41	54	.....	1	138
2	49	63	68	41	46	53	60	37	6	.....	.....	7
3	48	66	64	48	42	57	54	42	.....	.....	.....	.....
4	48	75	69	51	44	64	56	45	.....	.....	.....	3
5	45	76	62	54	41	63	57	48	T	.....	T	T
6	48	68	59	62	42	61	56	50	.....	35	.....	.....
7	48	73	59	52	43	61	54	50	.....	11	.....	.....
8	48	69	70	54	43	60	55	48	.....	52	.....	.....
9	52	68	78	68	48	61	66	53	.....	.....	.....	1
10	59	76	79	64	48	64	70	55	.....	.....	.....	63
11	68	62	74	65	56	48	69	53	.....	11	5	.....
12	60	42	72	65	53	38	65	60	54	.....	1	5
13	54	35	67	57	50	35	62	54	32	12	.....	.....
14	58	39	72	54	50	35	62	48	T	31	52	34
15	57	44	65	51	52	40	56	42	44	.....	1	4
16	50	50	67	53	45	43	56	45	46	.....	.....	.....
17	48	48	67	57	44	37	54	47	20	.....	9	.....
18	56	58	64	63	49	44	50	54	.....	.....	19	1
19	53	54	58	69	47	51	55	58	.....	8	3	.....
20	68	44	55	70	55	41	50	64	3	1	.....	47
21	66	46	67	52	60	37	57	47	.....	.....	.....	19
22	70	54	64	55	55	39	52	42	.....	.....	.....	.....
23	63	62	60	61	50	50	58	54	13	.....	.....	40
24	56	64	65	55	42	54	58	51	.....	.....	.....	19
25	70	64	67	53	50	56	54	48	.....	.....	19	T
26	50	63	71	52	46	53	66	47	20	39	.....	.....
27	58	49	67	54	49	43	58	45	T	.....	.....	.....
28	56	64	66	57	46	44	58	52	.....	.....	6	1
29	59	78	58	55	51	62	48	48	4	.....	3	.....
30	59	81	60	57	54	73	59	48	.....	.....	29	2
31	59	84	59	49	54	75	56	38	.....	.....	9	.....
Av.	55.8	60.5	66.2	56.5	48.4	51.3	57.6	48.8	.10	.06	.05	.128
								Total.	2.96	2.00	1.07	384
Number rainy days									14	9	14	17

DAILY TEMPERATURE AND PRECIPITATION AT SANDUSKY, OHIO, JUNE, 1893–1897.

Date.	Mean temperature.				Minimum temperature.				Daily precipitation.			
	1893.	1895.	1896.	1897.	1893.	1895.	1896.	1897.	1893.	1895.	1896.	1897.
1	68	82	57	52	58	76	50	49	5	.....	.....	.....
2	70	81	57	62	58	75	51	44	7	T	.....	T
3	74	84	62	72	65	74	56	65	2	.....	.....	31
4	74	76	66	59	65	66	56	54	23	39	14	.....
5	74	65	75	62	66	58	67	50	T	9	36	.....
6	68	58	77	66	64	50	66	56	3	.....	.....	0
7	64	62	78	57	54	46	67	54	.....	.....	1.21	59
8	68	64	72	59	56	51	67	54	.....	.....	24	.....
9	72	68	67	59	60	61	62	53	.....	.....	1	.....
10	76	70	65	60	69	61	60	53	.....	.....	T	.....
11	63	74	65	64	57	64	54	56	26	.....	.....	17
12	64	76	68	69	58	66	57	62	.....	.....	.....	.....
13	65	72	62	67	59	63	56	52	.....	T	.....	16
14	67	71	65	70	61	62	58	59	T	15	.....	.....
15	70	73	65	79	63	64	61	68	T	.....	35	T
16	70	69	64	66	65	66	58	56	11	.....	.....	13
17	72	71	65	70	63	66	58	65	.....	.....	.....	6
18	75	69	67	66	69	61	57	63	.....	.....	.....	10
19	74	70	73	71	63	69	62	64	.....	9	.....	6
20	80	62	79	63	70	62	70	60	T	22	.....	.....
21	78	65	79	57	72	65	70	49	13	3	32	.....
22	73	67	73	64	69	60	68	49	1	3	.....	.....
23	69	72	67	74	58	59	63	63	.....	.....	1	.....
24	73	72	69	77	61	68	62	70	.....	.....	30	T
25	73	77	78	69	66	66	66	66	T	3	T	.....
26	72	78	75	64	64	70	70	60	.....	4	.....	.....
27	70	69	73	61	62	64	66	53	.....	.....	.....	.....
28	70	68	68	65	65	64	60	56	.....	.....	T	.....
29	66	63	63	78	58	62	57	67	.....	.....	.....	45
30	68	61	69	81	60	62	59	72	.....	24	.....	1
Av.	71	69.5	68.1	66.6	62.6	63.4	61.2	58.4	.03	.05	.10	.....
								Total.	.91	1.61	2.94	.....
Number of rainy days.....									14	12	12	13

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